PUBLIC DOCUMENT . . . . No. 33.

TWELFTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1900.

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WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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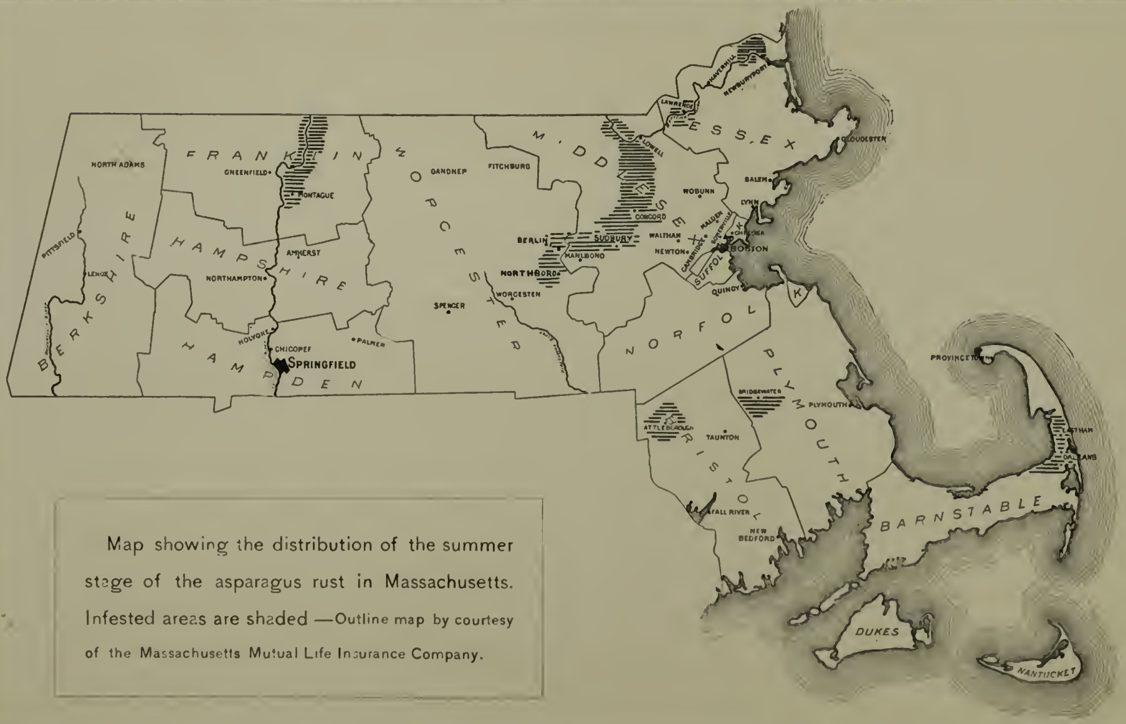

Map showing the distribution of the summer stage of the asparagus rust in Massachusetts. Infested areas are shaded —Outline map by courtesy of the Massachusetts Mutual Life Insurance Company.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are : —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Henry T. Fernald, Ph.D.,	*Associate Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
Samuel W. Wiley, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, M.Sc.,	*First Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant Chemist* (foods and feeding).
Philip H. Smith, B.Sc.,	*Assistant in Foods and Feeding.*
George A. Drew, B.Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand : —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 37. Report on fruits, insecticides and fungicides.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 43. Effects of electricity on germination of seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
No. 52. Variety tests of fruits; spraying calendar.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 57. Fertilizer analyses.
No. 58. Manurial requirements of crops.
No. 59. Fertilizer analyses.
No. 60. Insecticides; fungicides; spraying calendar.
No. 61. The asparagus rust in Massachusetts.
No. 63. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

The usual variety of problems have presented themselves for solution. In the agricultural division some interesting data have been collected on the use of sulfate and muriate of potash as fertilizers. With the sugar beet the larger yield was secured from the muriate, but the percentage of sugar was greater and the juice was of a higher degree of purity, presenting less difficulties in manufacture, from the sulfate. In sweet and field corn there was no perceptible difference in product, quality or food value, but with cabbages the yield was much greater from the use of the sulfate. In the tests of potatoes the Beauty of Hebron and Early Rose still rank in 94 varieties among the most productive sorts, either for early or late harvests. In feeding poultry a narrow *v.* a wide ration for egg-production, the results seemed to be largely in favor of the wide ration, richer in corn meal and corn, in the following particulars: (*a*) lower cost of feed, (*b*) a gain of 23 to 91 per cent. more eggs, (*c*) a lower cost per egg, (*d*) a greater increase in weight and (*e*) a much earlier moult.

In the meteorological division, besides the usual observation of weather phenomena, the means of the various weather elements for the last ten years have been tabulated, and normal conditions for the period deduced. Observations relating to soil temperature and moisture by electrical methods have been continued, and results from the corn-growing season of the current year have been worked out to serve as basis for comparison in succeeding years.

In the horticultural division, experiments have been carried on in the use of hydrocyanic acid gas under glass as an insecticide, but definite results have not yet been secured.

In the entomological division, the card catalogue to the literature of North American insects now numbers over forty thousand. The inspection of nurseries for the San José scale and the granting of authorized certificates has been added to the work of the division; bulletins on the coccid genera Chionaspis and Hemichionaspis and the grass thrips have been issued, and one on the clover-head beetle and a monograph of the Pyralidæ are ready for publication. The composition of Raupenleim, formerly imported at a high price, has been determined, and it can now be made at a trifling cost.

In the botanical division, interesting observations have been made on the distribution of the asparagus rust in Massachusetts and the relation existing between its outbreaks and the rainfall, together with the physical properties of the soil. There is a marked susceptibility of plants to this disease when grown in soil possessing little water-retaining properties, and a strong relation appears to exist between dry seasons and the occurrence of the summer or injurious stage of the rust.

The chemical division (foods and feeding) has analyzed during the year 2,045 substances, besides carrying on for the Association of Official Agricultural Chemists investigations relative to the best methods for the determination of starch, pentosans and galactan in agricultural products.

The chemical division (fertilizers) has issued 67 licenses to manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals, 38 of whom had offices of general distribution in Massachusetts; 384 samples of fertilizers were collected in the open markets by experienced assistants of the station, and 362 were analyzed and the results published in bulletins.

Reports from the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1899.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$4,216 31	
for labor,	5,167 16	
for publications,	1,090 45	
for postage and stationery,	242 31	
for freight and express,	122 39	
for heat, light and water,	164 77	
for chemical supplies,	3 45	
for seeds, plants and sundry supplies,	484 58	
for fertilizers,	1,076 40	
for feeding stuffs,	208 55	
for library,	411 65	
for tools, implements and machinery,	718 80	
for furniture and fixtures,	61 45	
for scientific apparatus,	201 90	
for live stock,	95 00	
for traveling expenses,	105 21	
for contingent expenses,	139 25	
for building and repairs,	490 37	
		$15,000 00

Cash received from State treasurer,	$11,200 00	
from fertilizer fees,	3,585 00	
from farm products,	1,641 78	
from miscellaneous sources,	1,906 71	
		$18,333 49

Cash paid for salaries,	$8,127 13
for labor,	4,275 48
for publications,	204 00
for postage and stationery,	211 49
for freight and express,	162 01
for heat, light and water,	583 59
Amount carried forward,	$13,563 70

Amount brought forward, . . .	$13,563 70	
Cash paid for chemical supplies, ...	842 90	
for seeds, plants and sundry supplies, .	752 76	
for fertilizers, ...	302 21	
for feeding stuffs, ...	443 36	
for library, ...	33 97	
for tools, implements and machinery, .	32 75	
for furniture and fixtures, . . .	227 68	
for scientific apparatus, . . .	108 27	
for live stock, ...	87 22	
for traveling expenses, . . .	272 70	
for contingent expenses, . . .	180 00	
for building and repairs, . . .	1,485 97	
		$18,333 49

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1899; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,333.49, and the corresponding disbursements $33,333.49. All the proper vouchers are on file, and have by me been examined and found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1899.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 11, 1899.

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

The work of the agricultural department of the station has been more extensive during the past year than ever before during its history. Besides the investigations selected for full discussion later in this report, we have carried on a large number of other out-door experiments, among which may be mentioned those having the following objects in view: with potatoes, to determine the best distance for planting; with oats, to determine relative value of equal money's worth of five different phosphates; with corn, to determine relative value of ten leading phosphates when used in quantities furnishing equal amounts of phosphoric acid; with orchard trees, to test the effects of five different systems of manuring; to test the value of employing nitragin for several of the crops of the clover family; to determine the adaptation and value of different grasses, forage and food crops.

We have put up a glass house for use in connection with pot experiments, and have installed a very complete equipment of iron tracks, trucks, pots, etc., for use in such experiments. The house is 23 by 60 feet, and contains six tracks. The track yard adjoining, which is enclosed by fine wire netting, is 28 by 80 feet. It contains seven tracks, on which the trucks carrying the pots stand during good weather, being quickly run into the house in case of rain or storm. It has transfer track, turn-table and an iron water tank. We have partitioned off a room (12 by 30 feet) in the old barn, cemented the floor, and connected the same with the glass house by iron track about 100 feet in length.

This serves as a work room in connection with pot experiments. We have this year carried on experiments with potatoes, onions, soy beans, corn and millet as crops, in which we have used 286 pots. The results are of much value, having assisted toward the solution of a number of important problems; but, as there remains much chemical work to be finished in connection therewith, these experiments cannot be reported at this time. Of the value of this method of experiment, which has so approved itself with European investigators, there can not be the slightest doubt; it will prove a most important adjunct to field work.

We have further carried out a number of experiments in cylinders 4 feet deep and 2 feet in diameter (without bottom), plunged to the rim in the open air and filled with equal amounts of carefully mixed earth. In these experiments we have employed sixty-three such cylinders, dealing with some important problems. This too proves a valuable method of work. Results are not yet sufficiently worked out for publication.

The report will touch in detail only upon experiments the results of which are sufficiently definite to permit practical deductions of value. The report on such experiments follows.

Soil Tests.

Two soil tests have been carried out upon our home grounds during the past season, both in continuation of previous work upon the same ground. The same kinds of fertilizers have been applied to each plot and in the same amounts as last year. In addition, each plot in the first test received an application of slaked lime, at the rate of one ton per acre; in the second test, one-half of each plot received an application of lime at the same rate. The lime was spread evenly early this spring, and harrowed in, both fields having been ploughed the previous fall.

Soil Test with Corn. Amherst.

The past is the eleventh season that the experiment on this field has been in progress. The crops in order of rotation have been corn, corn, oats, grass and clover, grass and clover, corn followed by mustard as a catch-crop, rye, soy beans, white mustard, corn, and this year corn once more. During all this time four of the fourteen plots into which the field is divided have received neither manure nor fertilizer; three having but a single important manurial element, nitrogen, phosphoric acid and potash, — every year the same; three have received each year two of these elements; one has received all three yearly; and one each has received yearly lime, plaster and farm-yard manure. It will be seen that the greater part of the field has remained either entirely unmanured or has had but a partial manuring, and it will be readily understood that the degree of exhaustion of most of the plots is considerable. The nothing plots produced this year an average of 4.6 bushels of shelled corn per acre and 767.5 pounds stover; and even this figure is somewhat misrepresentative, owing to the fact that after this long period two of the nothing plots which adjoin plots which have been yearly well manured begin to feel the effect of the high fertility of their neighbors, although separated from them by strips three and one-half feet wide.

The Effect of the Fertilizers.

The table shows clearly the marked differences undoubtedly due to the variation now eleven years continued in the fertilizer treatment. The fertilizers wherever employed are applied at the following rates per acre; nitrate of soda, 160 pounds (furnishing nitrogen); dissolved bone-black, 320 pounds (furnishing phosphoric acid); muriate of potash, 160 pounds (furnishing potash); land plaster, 160 pounds; lime, 160 pounds; and cow manure, 5 cords. All plots, it must be remembered, received also an application of lime at the rate of 1 ton per acre, in addition to the materials named in the table.

*South Acre Soil Test, 1899.**

Plot.	FERTILIZERS.	Yield per Acre.		Gain or Loss compared with Nothing Plots, per Acre.	
		Shelled Corn † (Bushels).	Stover † (Pounds).	Shelled Corn (Bushels).	Stover (Pounds).
1	Nitrate of soda, ...	13.75	1,160	9.87	430
2	Dissolved bone-black, . . .	3.50	620	—.38	—110
3	Nothing, ...	3.88	730	–	–
4	Muriate of potash, ...	49.75	2,760	45.50	2,000
5	Lime, ...	7.25	1,100	2.62	310
6	Nothing, ...	5.00	820	–	–
7	Manure, ...	75.88	5,350	70.88	4,530
8	Nitrate of soda and dissolved bone-black.	21.38	1,220	15.50	380
9	Nothing, ...	5.88	840	–	–
10	Nitrate of soda and muriate of potash.	47.88	2,360	42.75	1,573
11	Dissolved bone-black and muriate of potash.	59.88	3,160	55.50	2,427
12	Nothing, ...	3.63	680	–	–
13	Plaster, ...	6.63	990	3.00	310
14	Nitrate of soda, dissolved bone-black and muriate of potash.	72.88	4,450	69.25	3,770

* All plots limed at rate of one ton per acre.

† Both stover and ears were driest upon the plots giving the larger yields, viz., 4, 7, 10, 11 and 12, for only on these was growth sufficiently normal to allow natural ripening.

The Results in 1898.

[No lime had been used except on the lime plot.]

For purposes of comparison I here present a statement covering the results of last year (1898), when also the crop, as has been pointed out, was corn. I quote from my last annual report: —

The single-element plots, one receiving nitrate of soda only yearly, another phosphoric acid and the third potash, give this year practically equal crops of grain, respectively at the rate of 20.6, 18.5 and 19.8 bushels per acre. The nitrate of soda and dissolved bone-black give a crop at the rate of 32 bushels per acre, while nitrate of soda and potash give at the rate of but 10.9 bushels. The dissolved bone-black and muriate of potash do much better, yielding at the rate of 41.2 bushels. The fertilizer supplying nitrogen, phosphoric acid and potash gives a crop of 55.9 bushels, while manure gives 67.7 bushels.

It may be remembered that in each of the three previous years in which this field has produced corn the muriate of potash has, whether singly or in combination, proved much more useful than either of the other fertilizers used. There is much evidence in the behavior of the crops this year, during the growing season, and in the results, that this salt is proving injurious in its chemical effect upon the soil. I believe this effect to be a loss of lime in the form of chloride by leaching, but cannot regard this as yet proven. I will present the facts apparently bearing upon the case, and leave full discussion to a later report.

1. During the early part of the growing season the corn upon all the plots which had received muriate of potash was distinctly behind that upon other plots.

2. As the season advanced, the corn upon these plots gradually lost its sickly appearance, gained upon that in the other plots, eventually excelling, in the case of the plot receiving nitrogen, phosphoric acid and potash, that in all other plots except the manure plot.

3. This unhealthy appearance of the corn early in the season, followed by great improvement later, is analogous to effects noticed in other experiments,* where chlorides have been used, and where liming the land has remedied the faulty condition.

4. On that plot receiving dissolved bone-black as well as muriate of potash, the crop was in the end a good one. As is well known, the dissolved bone-black contains a large amount of sulfate of lime. It is believed that this may take the place of the lime leached from the soil as a consequence of the use of muriate of potash, or at least that it corrects in some way the faulty condition consequent upon the use of this salt. It may here be pointed out that a similar corrective influence is evident in the results obtained both in 1897 and 1898 upon our other soil test acre, which will immediately be discussed.

It is of interest, further, to point out that the crop this year upon the lime plot was not quite equal to the average of the nothing plots, while that of the plaster plot (sulfate of lime) was about double that of the lime plot. In the earlier years of this soil test the yield of neither the lime nor the plaster plot ever exceeded that of the nothings, but for the past three years the plaster plot has been relatively gaining. The explanation of this difference between the effect of plaster and lime is not apparent. It will be made the subject of future study. . . .

The problems suggested by the results of the year must be

* For example, Plot 6, Field A. See report State Experiment Station for 1896.

regarded as the most valuable product of this experiment. These problems are not solved. Their solution will throw important light upon methods to be employed in compounding and selecting fertilizers.

Conclusions (based upon Results in 1899).

1. By reference now to the table showing the yields for 1899, it will be seen that what last year was merely a suspicion, supported, it is true, by incidental observations in connection with other experiments, is apparently confirmed by the results of this year after liming, viz.: *that last year the application of potash failed to prove beneficial as in the earlier years when corn was grown, because its continued use in the form of muriate had resulted in depleting the soil of its lime.*

It should be noticed that I say "*apparently* confirmed." I would point out that the results of this experiment by themselves do not furnish absolute proof, for its plan is such that it does not enable us to decide that the superior results of the past season may not have been due to the fact that the lime proved beneficial through indirect effects which might have been exerted equally well by some other alkali, such as an alkaline salt of soda or of magnesia. To determine this point, two series of pot experiments with soil from two plots in this field have been carried out. In these, besides slaked lime, we have employed land plaster (sulfate of lime), carbonate and sulfate of magnesia, and bicarbonate and sulfate of soda. The results are not fully worked up, but they decisively indicate: (*a*) *That the benefit from the use of lime was not due to the fact that it corrected soil acidity.* (Sulfate of lime, a neutral salt, produced a better growth than slaked lime, while neither the carbonate of magnesia nor the carbonate of soda proved distinctly beneficial; the latter, indeed, was highly injurious.) (*b*) That it was not due to indirect action of any other sort. (Substances exercising similar chemical and physical influence upon the soil did not prove equally beneficial with the plaster or the slaked lime.)

2. The yield of each of the plots which has been manured with muriate of potash is largely increased. Alone and in

every combination it proves highly beneficial. *That this soil after eleven years' continuous application of muriate of potash at the rate of 160 pounds per acre annually should be capable after liming of producing corn at the rate of 49.75 bushels of shelled grain per acre, is astonishing.*

3. The crop, amounting to almost 60 bushels shelled corn per acre, on the plot which now for eleven years has yearly received only dissolved bone-black and muriate of potash (lime this year of course excepted) and which in this long period of time has received no addition of nitrogen in the form of manure or fertilizers, illustrates the remarkable extent to which, in our climate, the corn plant can thrive upon the natural stores of this element in the soil and that which it accumulates as a result of the introduction of clover into the rotation.

4. It will be noticed that where the elements nitrogen, phosphoric acid and potash have been yearly supplied, the crop this year, amounting to about 73 bushels per acre, is within three bushels of that produced where manure at the rate of 5 cords per acre has been annually applied. The fertilizers used (nitrate of soda, 160 pounds; dissolved bone-black, 320 pounds; and muriate of potash, 160 pounds per acre) cost about $10; while the manure, if purchased, would cost $25 at least in most parts of the State. It should be pointed out, however, that this soil has almost perfect physical characteristics. On the one hand, its perfect drainage insures freedom from excessive moisture even in wet seasons; and, on the other, the happy mean existing in the proportion of fine and coarse particles insures good water-conducting power (capillarity), and thus prevents injury from drought and injurious crust formation. In such a soil the organic matter furnished by manure is far less necessary than in those which are either more sandy or more clayey. For these reasons, fertilizers have doubtless made a more favorable showing as compared with manure than would usually be the case. The table shows the relative standing of the two plots, 7 (manure) and 14 (complete fertilizer), for the entire period of eleven years. It will be seen that the financial outcome where the fertilizer has been used is much better than for the plot receiving manure.

Increases as compared with Plot receiving no Manure.

Produced by Complete Fertilizer, 1889–99.

CROP.	Number Years grown.	Bushels.	Pounds.	Value of Increase.	Cost of Fertilizers.
Corn,	5	198.05	stover, 12,475	$107 29	$48 00
Oats,	1	15.63	straw, 1,720	14 70	9 60
Rye,	1	15.36	straw, 2,480	12 10	9 60
Soy beans,	1	–	beans, 880 straw, 840	4 61	9 60
Grass,	2	–	hay, 3,420 rowen, 1,360	37 56	19 20
Mustard,	1	–	5,100	–	19 20*
				$176 20	$115 20

Produced by Manure, 1889–99.

CROP.	Number Years grown.	Bushels.	Pounds.	Value of Increase.	Cost of Fertilizers.
Corn,	5	216.08	stover, 13,990	$117 79	$125 00
Oats,	1	18.13	straw, 3,260	22 11	25 00
Rye,	1	21.07	straw, 3,200	31 84	25 00
Soy beans,	1	–	beans, 1,520 straw, 3,880	77 26	25 00
Grass,	2	–	hay, 4,860 rowen, 3,460	64 27	50 00
Mustard,	1	–	8,500	–	50 00*
				$313 27	$300 00

* Double application of fertilizers and manure for mustard.

Soil Test with Onions. Amherst.

This experiment occupied a field which has been employed in work of this kind for ten years, the several plots having been every year manured alike, as described under the "Soil test with corn." The previous crops in the order of rotation have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes and onions. The land was ploughed in the fall of 1898 and reploughed early this past spring. Fertilizers were employed this year in the same quantities as last, viz., nitrate of soda at the rate of 320 pounds; dissolved bone-black, 640 pounds; and muriate of potash, 320 pounds, per acre. These fertilizers are each used upon one plot singly, in pairs, and upon one plot all three together. The west half of each plot was limed, as has been stated, at the rate of 1 ton per acre.

The seed was sown in the customary manner, but more thickly, on April 28. Germination was prompt and perfect.

The development upon the several plots and upon the unlimed and limed sections of all the plots exhibited the most remarkable differences.

1. Many of the plants upon the nothing plots soon died, and those remaining made practically no growth. The limed halves of these plots throughout the first half of the season were even worse in these respects than the unlimed.

2. The application of no single element without lime gave a good growth; but the plants upon the dissolved bone-black (without lime) did best. With lime the growth was more feeble than without it on the dissolved bone-black plot. On the plot on which muriate of potash was used without lime most of the plants soon died, while on this fertilizer alone and lime there was a rank growth, though few ripe bulbs were harvested. Nitrate of soda with lime gave better growth than without, but both with and without growth was very feeble.

3. On nitrate of soda and muriate of potash without lime almost all plants died; with lime there was a rank growth; but the bulbs did not ripen well.

4. On nitrate of soda and dissolved bone-black without lime was the best growth on the unlimed portion of the field. As last year, the development upon these two fertilizers alone was much better than on the plot where they were employed in the same amounts with muriate of potash. The growth upon the limed portion of the plot receiving the nitrate and bone-black was not materially improved, while where the muriate of potash was used with these fertilizers liming influenced the growth most favorably.

5. Liming proved highly favorable on the plot where dissolved bone-black and muriate of potash were used, this portion of that plot ranking third in the field in appearance throughout the season, while there was little growth upon the unlimed portion.

The Effect of the Fertilizers.

The tables give the results of the harvest: —

North Acre Soil Test, Onions, 1899.

Plots.	MANURING.	Results in Pounds, including Tops.			
		Yield per Acre.		Gain or Loss compared with Nothings, per Acre.	
		Unlimed.	Limed.	Unlimed.	Limed.
Plot 1,	Nothing,	2,950	3,180	-	-
Plot 2,	Nitrate of soda,	4,470	9,700	356.67	5,046.67
Plot 3,	Dissolved bone-black,	2,950	2,570	—2,323.33	—2,836.67
Plot 4,	Nothing,	6,440	6,520	-	-
Plot 5,	Muriate of potash,	3,270	24,740	—2,510	18,467.50
Plot 6,	Nitrate of soda and dissolved bone-black.	17,410	17,380	12,290	11,355
Plot 7,	Nitrate of soda and muriate of potash.	1,440	25,030	—3,020	19,252.50
Plot 8,	Nothing,	3,800	5,530	-	-
Plot 9,	Dissolved bone-black and muriate of potash.	11,090	19,510	7,680	13,815
Plot 10,	Nitrate of soda, dissolved bone-black and muriate of potash.	13,770	22,730	10,750	16,870
Plot 11,	Plaster,	1,550	1,610	—1,080	—4,415
Plot 12,	Nothing,	2,240	6,190	-	-

North Acre Soil Test, Onions, 1899.

Plots.	MANURING.	Results in Bushels of 52 Pounds of fairly cured Onions.			
		Yield per Acre.		Gain or Loss compared with Nothings, per Acre.	
		Unlimed	Limed.	Unlimed.	Limed.
Plot 1,	Nothing,	2.69	4.42	-	-
Plot 2,	Nitrate of soda,	18.65	91.43	15.13	79.77
Plot 3,	Dissolved bone-black,	6.53	12.31	2.17	—6.60
Plot 4,	Nothing,	5.19	26.15	-	-
Plot 5,	Muriate of potash,	3.07	161.75	—1.54	137.90
Plot 6,	Nitrate of soda and dissolved bone-black.	143.10	200.00	139.06	178.46
Plot 7,	Nitrate of soda and muriate of potash.	3.07	145.40	—.39	121.55
Plot 8,	Nothing,	2.88	16.93	-	-
Plot 9,	Dissolved bone-black and muriate of potash.	40.38	183.88	37.21	163.50
Plot 10,	Nitrate of soda, dissolved bone black and muriate of potash.	46.15	224.60	42.69	200.94
Plot 11,	Plaster,	4.04	6.35	.29	—20.68
Plot 12,	Nothing,	4.04	30.39	-	-

The Results and Conclusions based thereon in 1898.

In 1898 also the crop upon this field was onions, and it is desirable to present the leading statements and conclusions published that year for the purpose of comparison. The manuring was the same as this year, save that no lime was used. I quote from my last annual report: —

The results show that this [phosphoric acid, — dissolved bone-black] more than either the nitrogen or the potash supply controlled the product. The crop was very light, however, even upon the best plot, which was at the rate of 116.9 bushels per acre, upon the plot receiving nitrate of soda and dissolved bone-black. Upon the plots receiving these two fertilizers and muriate of potash the crop amounted to only 16.3 bushels per acre. Here is strong evidence that the muriate of potash has produced in the soil of this field conditions absolutely prejudicial to the growth of the onion.

Last year this field was in potatoes under the same system of manuring, but with half the quantities employed this year. The crop of potatoes on the nitrate and bone-black was much heavier than on these two and potash, and in commenting upon this fact in my annual report I wrote: "The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which these two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion that nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must, therefore, conclude that some disturbing factor, at present unknown, influenced the results."

In view of the similar relative results upon the two plots under discussion this year, I am now forced to conclude that I was mistaken last year in supposing that the superiority of the plot receiving nitrogen and phosphoric acid only was not "the effect of the fertilizer alone."

I now believe that the muriate of potash has proved actually injurious to the last two crops, and that the explanation (the loss of lime which it causes) already suggested accounts for this effect.

Conclusions (based upon Results in 1899).

1. A study of the tables giving the results of this year affords convincing presumptive evidence that the continued use of muriate of potash has so depleted this soil of lime that its use for the onion crop is a necessity. The suspicion of last year, just quoted, is apparently confirmed. The results obtained in two series of pot experiments (not yet fully worked up), in which soil from two plots in this field was used, force me, however, to look upon this conclusion as in a measure tentative; for in the pot experiments other alkalies proved almost, if not quite, as beneficial as lime, indicating that the presence of free acid in the soil may have been the cause of the poor growth upon most of the plots of this field. Even this conclusion cannot, however, be looked upon as final, for the substitution of sulfate for the muriate of potash in the pots resulted in good growth without the addition of any alkali. A full discussion of the subject is reserved for some future article.

2. We are meanwhile justified in the statement that both field and pot experiments show that the muriate is an undesirable form in which to apply potash for this crop, though the bad influence of the chlorine which it contains may possibly be neutralized by application of lime.*

3. The remarks of last year may in conclusion be appropriately quoted: —

The Proper Course as regards Potash Supply.

What, then, in view of our results, are we to recommend? Clearly not to cease using potash, — we have been unable to raise good crops without it. It is believed the remedy will be found in one of three directions, viz., (1) the occasional liberal use of lime where muriate of potash is employed; (2) the use of other potash salts, such as carbonate or sulfate; or (3) the employment of wood ashes as a source of potash. Should potash be supplied in the form of either carbonate or sulfate, lime leaches from the soil much less rapidly; the same is true of ashes, and these, moreover, sup-

* It is believed that the influence of the lime will be even more marked another year. It was applied, it will be remembered, this spring. Its action, as was anticipated, was not sufficiently prompt to prevent much injury to the onions, because of faulty soil conditions in the early part of the season. We have accordingly failed to produce a good yield on any plot this year.

ply much lime. This entire question, however, demands further experimental study, and I am not at present prepared to give definite advice upon this point.

Manure Alone *v.* Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a smaller application of manure used in connection with muriate of potash was begun in 1890. A full account will be found in the annual reports of 1890–96, and in 1895 a general summary of the results up to that date was given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn of 1896. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash was used in 1897. The field was kept in grass two years, and was manured as usual in 1898. It includes four plots, of one-fourth an acre each. The average results while in grass are shown below: —

Plots 1 and 3 (manure alone, 6 cords per acre, 1890–96): per acre, hay, 5,662 pounds; rowen, 3,218 pounds.

Plots 2 and 4 (manure, 3 cords per acre, 1890–92; 4 cords, 1893–96; and potash, 160 pounds per acre): per acre, hay, 4,540 pounds; rowen, 2,633 pounds.

The sod was turned in the autumn of 1898 and was manured this spring, as shown below: —

Plot 1, manure, 1½ cord; weight, 8,825 pounds.
Plot 2, { manure, 1 cord; weight, 5,880 pounds.
high-grade sulfate of potash, 40 pounds.
Plot 3, manure, 1½ cord; weight, 8,840 pounds.
Plot 4, { manure, 1 cord; weight, 5,880 pounds.
high-grade sulfate of potash, 40 pounds.

The crop this year has been corn (Sibley's Pride of the North), and its development appears to have been normal in all respects. The crop was a heavy one on all plots.

Yield per Plot.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1,	1,331	1,260
Plot 2,	1,331	1,160
Plot 3,	1,341	1,170
Plot 4,	1,355	1,110

Average Yield per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone),	66.8	4,860
Plots 2 and 4 (manure and potash),	67.2	4,540

It will be noticed that the crops are of practically equal value, — a little more grain on the manure and potash and a little more stover on the larger quantity of manure alone. The manure and potash used cost per acre nearly $7 less than the larger amount of manure used alone.

We have now grown seven corn crops on this field, and the average yields are at the rate per acre for the two manurings : —

Average of Seven Crops.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Manure alone,	61.5	4,562
Lesser manure and potash,	56.7	4,168

At prices which have prevailed during the period covered by this experiment the total manurial application where the manure and potash have been used has cost at the rate of $75 per acre less than on the other plots. The manure alone, however, has produced yields excelling the lesser manure and potash for the entire period at rates per acre amounting to: shelled corn, 33.6 bushels; corn stover, 2,758 pounds; hay, 2,244 pounds; and rowen, 1,170 pounds. These products would have been worth $46.50. In using the large amount of manure alone, then, one would in effect, allowing the manure to cost $5 per cord on the land, have expended $75 for products worth but little more than one-half that sum.

When, further, we note that at present the lesser manure and potash is producing the larger crop of grain, the superior economy of the system is evident.

"Special" Corn Fertilizer v. Fertilizer richer in Potash.

This experiment was begun with a view to comparing the results obtained with a fertilizer proportioned like the average "*special*" *corn fertilizers* found upon the markets in 1891 with those obtained with a fertilizer richer in potash, but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots, if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots, of one-fourth of an acre each. The materials supplied to the several plots are shown in the following table: —

FERTILIZERS.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	20.0	18.0
Dried blood,	30.0	30.0
Dry ground fish,	30.0	20.0
Plain superphosphate,	226.0	120.0
Muriate of potash,	22.5	60.0
Cost of materials per plot,	$3 23	$3 10

The field was kept in grass for two years, the average yields being at the rates per acre : "Special" fertilizer : hay, 2,730 pounds ; rowen, 1,122 ; fertilizer richer in potash : hay, 2,557.5 pounds ; rowen, 1,149 pounds. The "special," it will be seen, gave yearly 172.5 pounds more hay but 27 pounds less rowen than the other fertilizer. The larger nitrogen application accounts for the excess in hay ; the larger potash application to the other plot produces the more rowen. The stand of clover in the field was poor. It is believed that, had it been good, the differences in yield of rowen in favor of the fertilizer richer in potash would have been larger.

The sod was ploughed in the autumn of last year, fertilizers as usual applied and wheel-harrowed in this spring. The crop this year was corn, which made perfectly normal and good growth on all plots and gave a good yield.

Yield of Corn, 1899.

PLOTS.	Ears (Pounds).	Stover (Pounds).
Plot 1 (lesser potash),	1,257.5	1,090
Plot 2 (richer in potash),	1,141.0	1,140
Plot 3 (lesser potash),	1,168.5	1,120
Plot 4 (richer in potash),	1,200.5	1,120

Average Rates per Acre.

PLOTS.	Shelled Grain (Bushels).	Stover (Pounds).
Plots 1 and 3,	60.7	4,420
Plots 2 and 4,	58.5	4,520

The crops this year are almost equal, — the "special" giving a little more than 2 bushels more grain ; the fertilizer, richer in potash, 100 pounds more stover. The former gives somewhat the more valuable and the more profitable crop. The advantage, however, is insignificant, amounting to only 25 cents per acre.

The experiment has now been in progress nine years, and during seven of these years corn has been grown; on all plots five years and on two only of the plots two years. The averages for the seven years are given in the table: —

Average Yield Corn, Seven Years.

	Shelled Grain (Bushels per Acre).	Stover (Pounds per Acre).
"Special" fertilizer,	57.95	3,760
Fertilizer richer in potash,	50.41	4,033

During two years one-half this field was occupied by Japanese millet (*Panicum Italicum*). The average yields per year are shown in the table: —

Averages, Millet, Two Years.

	Millet Seed (Bushels per Acre).	Straw (Pounds per Acre).
"Special" fertilizer,	63.15	3,522
Fertilizer richer in potash,	66.55	3,735

It will be seen, then, that thus far the two systems of manuring stand nearly upon an equality. The fertilizer poorer in potash ("special") has given the more corn and the more hay. The other fertilizer, richer in potash, has given the more corn stover, rowen, millet seed and millet straw. At present the two stand practically equal, as shown by the corn crop of the past season, It is believed that by the frequent introduction of clover (of which we have not yet had a good catch) the fertilizer richer in potash will prove superior to the other.

Sulfate compared with Muriate of Potash for Various Crops. (Field B.)

This experiment has been in progress in its present essential features since 1893. From 1884 to 1889 the odd numbered plots, 11 to 21, were manured yearly at the rate of 200 pounds per acre of muriate of potash, while the even numbered plots received no potash. From 1889 to 1892 all plots were manured alike. Since 1892 each plot has received yearly bone meal at the rate of 600 pounds per acre, the odd numbered plots muriate of potash at the rate of 400 pounds, and the even numbered plots high-grade sulfate of potash at the same rate per acre. There are eleven plots, numbered 11 to 21. These plots have been used for a wide variety of crops during the seven years that the experiment has been continued. The crops during the past year have been sugar beets, sweet corn, cabbages, field corn and soy beans.

Sugar Beets (Sulfate v. Muriate of Potash).

Sugar beets of four varieties occupied plots 15 and 16. The yield on 15 (muriate of potash) amounted to 3,815 pounds (14.3 tons) per acre; the yield on 16 (sulfate of potash) amounted to 3,708 pounds (13.9 tons) per acre. Each variety was sampled and the value of the beets for sugar manufacture determined. With one exception the beets grown on the sulfate of potash showed considerably higher percentages of sugar and a juice of a higher degree of purity than those grown on the muriate. Though the latter gave a slightly higher yield, the sulfate produced more sugar and a juice offering less difficulties in manufacture. In the case of the one variety where the muriate gave the richer beet, it is believed that this was due to the fact that the sulfate beets selected for analysis were considerably larger than the others. The differences in quality between the beets grown on the two salts were not sufficiently great to materially affect their value for stock feeding.

Sweet Corn (Sulfate v. Muriate of Potash).

This crop (Moore's Concord) occupied plots 11 and 12. Our objects were: first, to study the effect of the two forms of potash on yield; second, to determine whether there was any difference in quality between the product of the two plots which would affect its value for the table; and, third, to determine whether there was any well-defined difference in composition of the entire plant (stalk and ear) which would affect the value for stock feeding.

1. *Product.* — The details concerning product are shown in the table: —

Sweet Corn.

	Weight of Entire Crop (Pounds).	Number of Ears.		Total Ears (Pounds).	Weight of Stover (Pounds).
		Large.	Small.		
Muriate of potash, . .	4,965	1,411	335	929.69	4,035.31
Sulfate of potash, . .	4,965	1,574	377	1,034.36	3,930.64

In the judgment of the men handling the crop, the plants stood slightly thicker on plot 12 than on plot 11, and it is likely that this accounts in large measure, if not entirely, for the greater number of ears on plot 12. It will be noticed that the total product was the same on the two plots.

2. *Quality for Table Use.* — Chemical examination of kernels of corn from the two plots showed no difference which can be regarded as significant; in fact, the differences are probably within the limits of error. It therefore appears that the chlorine of muriate did not exert the depressing effect on sugar formation that is often noticed with other crops.

3. *The Food Value of the Entire Plant.* — Analyses of the product of the two plots revealed no differences in composition which would materially affect the feeding value.

Field Corn (Eureka for the Silo) (Sulfate v. Muriate of Potash).

This crop occupied plots 19 and 20, and on both made a fine growth, averaging 15 feet in height. The ears were small and in the milk when the crop was ensiled, September 28. The yields (obtained by weighing after partial wilting) were: —

Muriate plot, 6,145 pounds, at rate of 23 tons per acre.
Sulfate plot, 5,675 pounds, at rate of 21.2 tons per acre.

Feeding Value. — The crop from both plots was sampled for analysis. The results showed no important differences in the feeding value of the product on the two salts.

Maercker* has quoted Moser to the effect that corn raised on muriate of potash contains more protein, and therefore has a higher food value, than when grown on sulfate. Three experiments here, one in 1898 and the two this year, have not shown this to be the case. It would appear that the muriate of potash is equally as good for the corn crop as the sulfate.

Soy Beans (*Sulfate v. Muriate of Potash*).

Through accident the product of the soy bean plots was mixed; and I can only report that during the early part of the season the beans on the sulfate appeared much better than the others. Later this apparent superiority was lost in large measure, as judged after careful examination.

Cabbages (*Sulfate v. Muriate of Potash*).

This crop (Warren cabbage) occupied plots 13 and 14. The growth on the sulfate of potash was from the start much better than on the muriate, and this superiority was maintained throughout the season. The yield is shown in the table: —

	Number of Hard Heads, November 2.	Total Weight (Pounds).		Loose Leaves (Pounds).
		Hard Heads.	Soft Heads.	
Muriate of potash, . .	393	4,105	720	750
Sulfate of potash, . .	502	5,475	255	1,060

It will be noticed that the sulfate of potash plot gave much the larger and more valuable crop. It should be pointed out that, on account of difference of growth due to accidental conditions, the above table has been made to include the yield for only about one-ninth of an acre. The product of plot 14 sold at a price (5 cents per head) which would have made the product of one acre of such cabbages worth about $250, while the product of the other plot was worth only at the rate of about $200 per acre.

* Die Kalidungung, p. 252.

Comparison of Different Potash Salts. (Field G.)

The object in this experiment is to determine the relative manurial value for our various crops of the different prominent potash salts. The experiment was begun in 1898, the crop that year being the soy bean. The results were indecisive and unsatisfactory, the crop where no potash was used in numerous instances being as great as where potash manures were applied. The potash resources of the soil were clearly too large to allow satisfactory deductions to be made. This had, however, been anticipated. From the nature of the problem it was recognized that the experiment must continue for a series of years. We must study not simply the immediate effect upon the crop, but the effect upon the soil of long-continued use of the different salts, — and as well the effect upon the crop of such continued use.

In this experiment the plots are one-fortieth of an acre each, duly separated by dividing strips. There are forty plots, each manuring being five times duplicated. Every plot receives yearly materials estimated to furnish nitrogen and phosphoric acid in liberal amounts. All receive the same materials, save plots 6, 14, 22, 30 and 38, on which the potash salt used is the nitrate, so that the amount of nitrate of soda for these is made only sufficient (.5 pounds) to furnish to these plots the same amount of nitrate nitrogen as to the others. With this exception, the materials applied as sources of nitrogen and phosphoric acid are, per plot: —

	Pounds.
Nitrate of soda,	7.0
Tankage,	7.5
Acid phosphate,	10.0

In order to make certain that there should be no failure through deficiency of lime, the entire field received an application at the rate of one ton to the acre of lime freshly slacked, which was wheel-harrowed in early in the spring of 1898.

The various potash salts where used were applied in amounts intended to furnish an equal quantity of actual potash (K_2O) to each plot, as follows: —

		Pounds.
Plot 1.	No potash.	
Plot 2.	Kainite,	27.75
Plot 3.	High-grade sulfate of potash,	7.50
Plot 4.	Low-grade sulfate of potash,	15.00
Plot 5.	Muriate of potash,	7.50
Plot 6.	Nitrate of potash,	8.25
Plot 7.	Carbonate of potash-magnesia,	20.00
Plot 8.	Silicate of potash,	17.00

Plots 9–16, 17–24, 25–32 and 33–40 are duplicates respectively of plots 1–8.

The crop this year (the second of the experiment) was potatoes, Beauty of Hebron, seed from Maine. It was planted in drills, one set (2–3 eyes) in 14 inches. The tubers were subjected to the formalin treatment, to prevent scab, being soaked two hours in a solution of eight ounces to 15 gallons of water. They were budded in a light room after treatment, before being planted on May 8–9. The crop was well cared for, and sprayed repeatedly with Bordeaux mixture, to prevent blight, of which there was little. The yield was heavy, varying from 297 to 380 bushels of merchantable potatoes per acre on the different potash salts. The results are not entirely conclusive, for the reason that in duplicate plots the yields of the different salts do not occupy the same relative rank. Thus, for example, the various salts made the following relative yields in merchantable tubers : —

Kainite stands : —
1st, once ; 3d, once ; 6th, twice ; and 7th, once.
High-grade sulfate of potash stands : —
1st, twice ; 2d, twice ; and 3d, once.
Low-grade sulfate of potash stands : —
2d, twice ; 3d, once ; 6th, once ; and 7th, once.
Muriate of potash stands : —
1st, once ; 4th, twice ; 5th, once ; and 6th, once.
Nitrate of potash stands : —
Once each : 3d, 4th, 5th, 6th and 7th.
Carbonate of potash-magnesia stands : —
1st, twice ; 3d, twice ; and 5th, once.
Silicate of potash stands : —
4th, twice ; 6th, twice ; and 7th, once.

With such variations in relative standing, it will be agreed we must interpret results with caution. Still, it is believed that the average yield of the different salts should be published as a matter of record : —

Average Yield of Plots.

PLOTS.	POUNDS PER PLOT.		BUSHELS PER ACRE.	
	Large.*	Small.	Large.*	Small.
No potash,	430.70	61.00	287.13	40.66
Kainite,	488.45	52.60	326.83	33.86
High-grade sulfate,	525.70	52.95	350.46	35.49
Low-grade sulfate,	508.20	55.70	338.79	37.13
Muriate,	506.30	61.40	337.53	40.93
Nitrate,	498.20	64.75	332.13	43.16
Carbonate,	518.00	64.80	345.33	43.39
Silicate,	492.40	56.00	328.26	38.39

* Two ounces or over.

Conclusions.

1. It will be noticed that the soil is potash hungry, for every one of the salts used increases the yield.

2. The high-grade sulfate of potash stands first. It has with rare exceptions been found more effective in increasing the yield than the muriate, with which it has been frequently compared, and it gives better quality. We are justified in the conclusion that the application of potash in this form for the potato will give good results. It should be pointed out that our soil is moderately heavy and retentive. On drier sorts the muriate may compare with the sulfate more favorably.

3. The comparatively new carbonate of potash-magnesia ranks second. It is as carbonate that potash exists in wood ashes, which, however, are believed to favor some forms of scab. The fertilizer did not have that effect. This appears to be, then, a very useful form of potash. In mechanical condition it leaves nothing to be desired, being fine and remaining dry under all conditions of weather. The price is at present too high to allow its general use.

4. The low-grade sulfate of potash ranks third; but, as freights cost more per unit of potash for this salt than for the high grade, the latter is generally to be preferred. It is not impossible that in some localities the magnesia of the low-grade sulfate may prove useful; but we have no evidence that such is the case here.

5. The kainite ranks lowest among all the salts employed. Since this, containing only about 13 per cent. of actual potash, can be purchased at a much lower ton price than the purer salts, such as the high-grade sulfate and the muriate, it is sometimes selected by farmers. It should be remembered that the unit of potash on the farm usually costs more in the kainite than in the others. In view of our results, then, I can see no reason for selecting this potash fertilizer.

6. The silicate of potash gives the next lowest crop. It is apparently slowly available. The present cost is high, and it can be kept from caking only by admixture with powdered peat or similar material. It is prepared especially for use on tobacco, for which crop it is under trial in Germany and in this country. I judge it will have no application for ordinary crops; and its usefulness for tobacco is not fully demonstrated, though some favorable results have been obtained.

Leguminous Crops (Clover, Pea and Bean or "Pod" Family) as Nitrogen Gatherers. (Field A.)

This experiment is a continuation of a series begun in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulfate of ammonia, dried blood and farm-yard manure as sources of nitrogen.*

The plots, eleven in number, are one-tenth acre each, and are numbered 0 to 10. Three plots (4, 7 and 9) have re-

* Only such details are given here as are necessary to an understanding of the nature of the experiment. Full particulars will be found in our ninth and tenth annual reports.

ceived no nitrogen-containing manure or fertilizers since 1884; one (0) has received farm-yard manure; two (1 and 2), nitrate of soda; three (5, 6 and 8), sulfate of ammonia; and two (3 and 10), dried blood every year since 1889. These materials have been used in amounts to furnish nitrogen at the rate of 45 pounds per acre each year.

All plots have received yearly equal quantities of phosphoric acid and potash; viz., 80 pounds per acre of the former and 125 pounds of the latter from 1889 to 1894 and the past four seasons; but in 1894 and 1895, double these quantities. To some of the plots the potash is applied in the form of potash-magnesia sulfate; to others, in the form of muriate. The results with the former salt have been superior to those with the latter, as a rule, particularly when used in connection with sulfate of ammonia. The entire field received at the rate of 1 ton per acre of partially air-slacked lime in the spring of 1898, in addition to the usual fertilizers.

Up to this year we may briefly characterize the results, in so far as these have a bearing upon the two main questions proposed, as follows: —

1. The leguminous crops grown (soy beans in 1892, 1894 and 1896) have not appeared to enrich the soil in nitrogen, if we accept the results with the next following crop as affording a basis of judgment.

2. The different sources of nitrogen have ranked on the average in the following order: nitrate of soda, farm-yard manure, dried blood and sulfate of ammonia.

The crop in 1898 was oats. After harvesting them, the land was ploughed and sown to what was supposed to be mammoth red clover in August. The variety appears to be the common red. This went into the winter in excellent condition, but was somewhat winter-killed on all plots, apparently for reasons unconnected with the manures which had been employed. The injury was most severe on plots 0, 5 and 8, and least on plot 5. Between the other plots there was little difference in the degree of injury, if we except plot 6, on which it was greater than on the others. Seed was sown on the surface this spring where needed. This germinated well, but the young plants made little growth, on account of the dry weather. Two crops were cut, the first on July 3. The plants at this time had ceased growth, on account of drought. Not all had blossomed, yet the condition must be classed as mature. The yield was seriously decreased by the dry weather. The second crop was cut August 21, being somewhat mixed with annual grasses, but apparently to equal degree in all plots. The hay was secured in good condition, being cured mostly in the cock. The table shows the fertilizer treatment and the yields of the several plots : —

Nitrogen Experiment, — Fertilizers used and Yield of Clover.

Plots.	FERTILIZERS.	Pounds.	Clover Hay (Pounds).	Clover Rowen (Pounds).	Total (Pounds).
Plot 0,	Barn-yard manure, Potash-magnesia sulfate, Dissolved bone-black,	800.0 32.0 18.0	220.0	288.3	508.3
Plot 1,	Nitrate of soda, Potash-magnesia sulfate, Dissolved bone-black,	29.0 48.5 50.0	200.0	243.8	443.8
Plot 2,	Nitrate of soda, Potash-magnesia sulfate, Dissolved bone-black,	29.0 48.5 50.0	220.0	202.6	422.6
Plot 3,	Dried blood, Muriate of potash, Dissolved bone-black,	43.0 25.0 50.0	120.0	225.8	345.8
Plot 4,	Muriate of potash, Dissolved bone-black,	25.0 50.0	140.0	196.8	336.8
Plot 5,	Ammonium sulfate, Potash-magnesia sulfate, Dissolved bone-black,	22.5 48.5 50.0	140.0	202.1	342.1
Plot 6,	Ammonium sulfate, Muriate of potash, Dissolved bone-black,	22.5 25.0 50.0	140.0	235.6	375.6
Plot 7,	Muriate of potash, Dissolved bone-black,	25.0 50.0	180.0	162.9	342.9
Plot 8,	Ammonium sulfate, Muriate of potash, Dissolved bone-black,	22.5 25.0 50.0	200.0	207.5	407.5
Plot 9,	Muriate of potash, Dissolved bone-black,	25.0 50.0	215.0	206.5	421.5
Plot 10,	Dried blood, Potash-magnesia sulfate, Dissolved bone-black,	43.0 48.5 40.0	215.0	241.5	456.5

It is perhaps questionable whether much weight should be attached to the yields at the first cutting, since full development was not reached on account of drought. The rowen gives a better basis for comparison. Studying these figures, we find the following points bearing upon the problem on which the experiment seeks to shed light : —

1. *The various materials furnishing nitrogen rank in the following order: manure, dried blood, nitrate of soda and sulfate of ammonia.*

2. *The plots receiving no nitrogen approach in average yield much more closely to those getting this element than has been the case with any previous crop on this land. This must be regarded as highly significant, for it will be remembered that this field has been under experiment for eleven years, and in all that time these plots have received no nitrogenous manure or fertilizer of any kind. The clover must, it seems evident, have drawn from the air for this element, in which, as is well known, it is especially rich.*

Fertilizers for Garden Crops. (Field C.)

This series of experiments was begun in 1891, and has for its objects to test the relative value for garden crops: (1) of sulfate of ammonia, nitrate of soda and dried blood as sources of nitrogen; and (2) of muriate and sulfate as sources of potash. For full details concerning the methods followed and earlier results, reference is made to my eleventh annual report. It should, however, be pointed out here that partially rotted stable manure has been applied in equal amounts to all the plots for the last two years. The amount of such manure used this year was 7,200 pounds per plot. The fertilizers used were as follows: —

Annual Supply of Manurial Substances (Pounds).

Plot 1,	Sulfate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 4,	Sulfate of ammonia,	38
	Sulfate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulfate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulfate of potash,	30
	Dissolved bone-black,	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply at the rates per acre: phosphoric acid, 50.4 pounds; nitrogen, 60 pounds; potash, 120 pounds. For purposes of comparison, I quote from my last annual report: —

Conclusions based on Results up to 1897. (Fertilizers Alone.)

The chief conclusions which seemed justified by the results with fertilizers alone are the following: —

1. Sulfate of potash in connection with nitrate of soda (plot 5) has generally given the best crop. In those cases where this has not been true, the inferiority of this combination has usually been small. In one case only has it fallen much behind, viz., with sweet corn, a crop which makes much of its growth in the latter part of the season.

2. Nitrate of soda (plots 2 and 5) has in almost every instance proved the most valuable source of nitrogen, whether used with the muriate or the sulfate of potash.

3. The combination of sulfate of ammonia and muriate of potash (plot 1) has in every instance given the poorest crop. This fact is apparently due, as Dr. Goessmann has pointed out, to an interchange of acids and bases leading to the formation of chloride of ammonia, which injuriously affects growth.

The Experiment in 1899.

The crops on each plot this year included the following: fruiting strawberries, celery (following the strawberries), cabbages, squashes, spinach, lettuce, table beets, onions and freshly set strawberries. Both manure and fertilizers were spread on after ploughing this spring and harrowed in.

Strawberries: — The vines of the fruiting beds were set in the spring of 1898. They all made good growth, but were somewhat winter-killed, apparently because covered rather too heavily. The injury was not very materially different on the different plots, but was judged to have been somewhat most serious on plots 0 and 2 and least on plot 4. Picking began on June 15 and ended on July 12. Plot 0 (manure alone) much exceeded the others in yield of ripe fruit at first, and in aggregate yield was excelled by but two of the plots. The total yields in pounds per plot were as follows: plot 0, 126.6 pounds; plot 1, 94.7 pounds; plot

2, 96.6 pounds; plot 3, 155.1 pounds; plot 4, 172.3 pounds; plot 5, 108.1 pounds; plot 6, 103.3 pounds.

The average yields in pounds produced by the different fertilizers* were: —

Manure alone (plot 0),	126.6
Average of manure and muriate of potash (plots 1, 2 and 3),	115.4
Average of manure and sulfate of potash (plots, 4, 5 and 6),	128.8
Average of manure and sulfate of ammonia (plots 1 and 4),	161.9
Average of manure and nitrate of soda (plots 2 and 5),	102.3
Average of manure and dried blood (plots 3 and 6),	129.2

It will be noticed that but two of the combinations of fertilizers used with the manure excel the manure alone, viz., sulfate of ammonia and sulfate of potash, and dried blood and muriate of potash. Nitrate of soda, which we have found the best source of nitrogen for most crops, makes the poorest showing. Between the muriate and sulfate of potash there seems to be no clearly defined difference. These results were doubtless in part determined by the degree of winter injury.

Celery. — This crop followed the strawberries without extra manuring. The share of the stable manure belonging to the fruiting strawberry area was, however, applied when the strawberry vines were turned in. The yields of the several plots in pounds were as follows: plot 0, 720.8; plot 1, 250; plot 2, 550; plot 3, 510; plot 4, 190; plot 5, 585; plot 6, 550.

The average yields in pounds produced by the different fertilizers were: —

Manure alone,	720.8
Manure and muriate of potash (plots 1, 2 and 3),	436.7
Manure and sulfate of potash (plots 4, 5 and 6),.	441.7
Manure and sulfate of ammonia (plots 1 and 4),	220.0
Manure and nitrate of soda (plots 2 and 5),	567.5
Manure and dried blood (plots 3 and 6),	530.0

* To enable the reader to better make comparisons, the plots are characterized as "manure and muriate of potash," "manure and sulfate of potash," etc. It should be remembered that dissolved bone-black was applied to all except plot 0, and that every plot except plot 0 received material supplying both nitrogen and potash as well as phosphoric acid in addition to the manure. For the full list of fertilizers applied to each plot, see page 35.

It will be noted that the manure alone gave much the largest crop.* Discussion as to the effect of the fertilizers, then, hardly seems called for. It is not without interest, however, to note that the crops where sulfate of ammonia was employed were much the smallest in the field. The result last year was similar in this respect.

Hanson Lettuce. — In harvesting this crop the heads of market size were cut from day to day. The total yields per plot in pounds were: plot 0, 83.1; plot 1, 54.75; plot 2, 129.25; plot 3, 150.50; plot 4, 88.5; plot 5, 148; plot 6, 122.25.

The average yields in pounds on the different fertilizers were: —

Manure alone (plot 0),	83.1
Manure and muriate of potash (plots 1, 2 and 3),	111.5
Manure and sulfate of potash (plots 4, 5 and 6),	119.6
Manure and sulfate of ammonia (plots 1 and 4),	71.6
Manure and nitrate of soda (plots 2 and 5),	138.6
Manure and dried blood (plots 3 and 6),	136.4

The sulfate of potash proves somewhat superior to the muriate; but the most marked result is the highly unfavorable influence of the sulfate of ammonia. This, as in previous years, in combination with the muriate of potash acts as a plant poison.

Spinach. — This, like the lettuce, was cut from time to time as it became ready for market. The yields in pounds of the several plots were: plot 0, 83.8; plot 1, 3; plot 2, 36.8; plot 3, 46.5; plot 4, 42; plot 5, 75.25; plot 6, 56.5.

The averages on the several fertilizers in pounds were: —

Manure alone (plot 0),	83.8
Manure and muriate of potash (plots 1, 2 and 3),	28.8
Manure and sulfate of potash (plots 4, 5 and 6),	57.9
Manure and sulfate of ammonia (plots 1 and 4),	22.5
Manure and nitrate of soda (plots 2 and 5),	56.0
Manure and dried blood (plots 3 and 6),	51.5

It is noticeable that manure alone produces a considerably larger crop than manure with any combination of fertilizers.

* In explanation of this fact, it should be pointed out that plot 0 previous to 1898 had entirely different manuring and cropping from the other plots. See last annual report. It is not believed that the fertilizers were injurious, as a rule.

The most marked effect is the injurious influence of the sulfate of ammonia.

Onions. — The yields of the several plots are shown in the table : —

PLOTS.	Well-cured Onions (Pounds).	Well-formed Onions, but not cured (Pounds).	Scallions (Pounds).
Plot 0,	1,334.5	26.5	13.0
Plot 1,	214.8	108.5	108.3
Plot 2,	1,174.0	75.0	24.0
Plot 3,	761.5	184.0	157.0
Plot 4,	632.7	248.5	93.0
Plot 5,	1,415.8	81.0	17.0
Plot 6,	929.3	243.8	79.8

The averages on the several fertilizers were : —

	Merchantable (Pounds).	Green (Pounds).	Scallions (Pounds).
Manure alone (plot 0),	1,334.5	26.5	13.0
Manure and muriate of potash (plots 1, 2 and 3),	716.8	122.5	96.4
Manure and sulfate of potash (plots 4, 5 and 6),	992.6	191.1	63.3
Manure and sulfate of ammonia (plots 1 and 4),	423.7	178.5	100.6
Manure and nitrate of soda (plots 2 and 5),	1,294.9	78.0	20.5
Manure and dried blood (plots 3 and 6),	845.4	213.9	118.9

It becomes evident from these figures (1) that none of the fertilizer combinations except one (nitrate of soda and sulfate of potash) benefited the crop, (2) that the sulfate is much superior to the muriate as a source of potash, and (3) that the nitrate of soda is much the best source of nitrogen.

Table Beets. — With this crop the manure alone gave much the best yields, and the several fertilizer combinations failed to produce effects sufficiently marked to warrant discussion. The details, therefore, will not be given.

Cabbages. — But one plot in this crop gave a yield excelling the manure alone, and that was the one receiving, in addition to manure, sulfate of ammonia and muriate of potash. The yields in hard heads in pounds were as follows :

plot 0, 375.1; plot 1, 420; plot 2, 377.5; plot 3, 337.5; plot 4, 347.5; plot 5, 207.5; plot 6, 320.

The averages on the several fertilizers in pounds were: —

	Hard Heads.	Soft Heads.
Manure alone (plot 0),	375.1	223.9
Manure and muriate of potash (plots 1, 2 and 3),	378.3	29.2
Manure and sulfate of potash (plots 4, 5 and 6),	291.7	29.2
Manure and sulfate of ammonia (plots 1 and 4),	383.7	12.5
Manure and nitrate of soda (plots 2 and 5),	292.5	52.5
Manure and dried blood (plots 3 and 6),	328.6	22.5

So far as results justify conclusions, it would seem (1) that the muriate shows itself superior to the sulfate of potash for this crop *when used with stable manure*, and (2) that the sulfate of ammonia is the best source of nitrogen for it. That the sulfate of ammonia should prove the most useful form of nitrogen supply with a crop making most of its growth in the latter part of the season we have before observed.*

In other experiments with cabbages this year, where fertilizers alone were used, the sulfate of potash gave much larger yields than the muriate.† Here this is reversed. I have at present no explanation to offer for this difference.

Squashes. — This crop gave much the best yield on manure alone, and the differences apparently produced by the several fertilizers are not significant. The sulfate gives larger yields than the muriate of potash in every case, while the sulfate of ammonia makes the lowest showing among the fertilizers supplying nitrogen. The details will not be given.

Variety Tests with Potatoes.

The number of varieties tested this year was 94. The seed used was all of our own raising. It was produced under conditions similar in every respect and had been similarly preserved. Of each variety, with a few exceptions later noted, 80 sets were planted at the distance of 1 foot

* See eleventh annual report.

† See page 28.

in drills 3 feet apart. One-half of these were harvested at early market maturity (August 1), the balance at full maturity (September 22–23).

The soil was a medium loam, in mixed grass and clover for the two preceding years. It received an application of farm manure at the rate of about 5 cords per acre on the sod early this spring, and was then ploughed. The fertilizers used in pounds per acre were: —

Nitrate of soda,	240
Acid phosphate,	400
Sulfate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were thoroughly mixed and scattered widely in the open furrow before dropping the seed. The seed potatoes were first washed and then treated in formalin solution (8 ounces to 15 gallons water) for two hours. The tubers were budded in a light room after treatment. The planting was done May 4 and 5. The crop was well cared for, and sprayed six times with Bordeaux mixture, to prevent blight, of which, however, there was considerable. The development was normal, save for the blight; and the yields and quality for the most part good. There was practically no scab.

The tables give data for the earlier and the latter diggings: —

Variety Test Potatoes. Record to Aug. 1, 1899.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.*	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Abundance,	June 23,	July 22,	1/16	148.5	24.3
Acme,	June 23,	July 19,	1/2	244.0	24.3
Algoma,	June 28,	July 22,	1/4	154.5	40.9
American Beauty,	June 17,	July 22,	1/4	200.0	10.6
Arizona,	June 17,	July 18,	1/4	224.3	51.5
Bartlett,	June 28,	July 24,	1/16	181.8	36.4
Beauty of Hebron,	June 19,	July 24,	1/8	260.6	40.9

* Fractions indicate proportion of foliage destroyed.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	Yield at Rate per Acre. Large, Two Ounces (Bushels).	Small (Bushels).
Burpee's Superior,	June 23,	July 22,	⅛	236.4	39.4
Burr's No. 1,	June 19,	July 22,	¼	262.1	45.5
Cambridge Russet,	June 23,	July 18,	¼	166.7	24.3
Carmen No. 1,	June 19,	July 22,	⅝	295.5	30.3
Champion of the World,	June 19,	July 22,	⅛	206.1	31.8
Clay Rose,	June 17,	July 18,	¼	239.4	39.4
Commercial,	June 28,	July 22,	¼	209.1	12.1
Country Gentleman,	June 19,	July 22,	⅛	251.5	33.3
Dakota Red,	June 30,	July 18,	½	184.9	27.3
Dreer's Standard,	June 23,	July 22,	¼	272.8	21.2
Dutton's Seedling,	June 19,	July 22,	⅛	298.5	36.4
Early Kansas,	June 19,	July 22,	⅛	298.5	33.3
Beauty of Hebron,	June 19,	July 24,	Trace.	287.9	31.8
Early Minnesota,	June 28,	July 18,	⅜	190.9	27.3
Early Roberts,	June 19,	July 22,	⅜	300.0	63.6
Early Rochester,	June 19,	July 22,	⅜	230.3	15.2
Early Rose,	June 19,	July 18,	½	263.6	51.5
Early Sunrise,	June 19,	July 18,	¼	221.2	51.5
Extra Early Vermont,	June 19,	July 15,	⅜	266.7	42.4
Empire State,	June 28,	July 22,	¼	148.5	24.3
Enormous,	June 19,	July 22,	⅛	275.8	9.1
Everett,	June 19,	July 15,	½	207.6	45.5
Fillbasket,	June 17,	July 20,	1/16	223.0	51.5
Garfield,	June 19,	July 22,	⅛	193.9	33.3
German Queen,	June 19,	July 22,	¼	213.7	24.3
Good Times,	July 6,	July 29,	Trace.	151.5	21.2
Governor Rusk,	June 28,	July 20,	⅜	236.4	9.1
Green Mountain,	June 23,	July 24,	⅛	127.3	18.2
Howard,	June 19,	July 24,	⅛	275.8	33.3
Hurst,	June 28,	July 15,	¾	-	-
Mill's Longkeeper,	June 23,	July 20,	¼	-	-
Irish Cobbler,	June 17,	July 20,	⅜	260.6	30.3
Joseph,	July 6,	July 24,	¼*	169.7	28.8
King of the Earliest,	-	July 22,	⅜	265.2	24.3
King of Roses,	June 19,	July 22,	¼	209.1	54.6
Lakeside Champion,	June 19,	July 20,	⅜	245.5	39.4

* Ripening.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	Yield at Rate per Acre.	
				Large, Two Ounces (Bushels).	Small (Bushels).
Late Puritan,	June 23,	July 24,	1/8	224.3	48.5
Lee's Favorite,	June 19,	July 22,	1/4	278.8	47.0
Leonard Rose,	June 19,	July 20,	1/4	239.4	42.4
Lincoln,	June 19,	July 29,	1/8	212.1	37.9
Maule's Thoroughbred,	June 19,	July 22,	3/16	260.6	48.5
Mayflower,	–	July 22,	1/4	124.3	42.4
Mill's Banner,	June 23,	July 29,	Trace.	112.1	15.2
Mill's Prize,	June 28,	July 22,	Trace.	154.5	18.2
Money Maker,	June 23,	July 22,	1/8	145.5	12.1
Montana Wonder,	June 17,	July 22,	3/8	260.6	33.3
New Satisfaction,	June 19,	July 22,	1/4	190.9	18.2
Parker's Market,	June 23,	July 22,	1/2	218.2	30.3
Penn Manor,	June 19,	July 22,	3/8	284.9	39.4
Pingree,	June 23,	July 22,	1/4	190.9	37.3
Prince Bismark,	June 19,	July 22,	3/8	269.7	21.2
Prize Taker,	June 23,	July 22,	1/2	244.0	25.8
Early Potentate,	–	July 20,	1/2	187.9	30.3
Pride of Michigan,	June 19,	July 22,	1/4	209.1	50.0
Prolific Rose,	June 19,	July 22,	1/8	257.6	51.5
Quick Crop,	June 19,	July 22,	1/8	221.2	54.6
Reeve's Rose,	June 19,	July 22,	1/8	187.9	36.4
Restaurant,	June 23,	July 24,	1/16	212.1	36.4
Rochester Rose,	June 19,	July 22,	1/8	212.1	48.5
Rose of Erin,	June 28,	July 22,	1/4	221.2	9.1
Rose No. 9,	June 28,	July 22,	1/8	106.1	53.0
Secretary Wilson,	June 19,	July 22,	3/8*	266.7	60.6
Seneca Beauty,	June 19,	July 24,	1/8	209.1	24.3
Sir Walter Raleigh,	July 6,	July 29,	Trace.	148.5	21.2
Sir William,	June 19,	July 22,	3/8	181.8	21.2
Signal,	June 19,	July 22,	3/8	251.5	45.5
Somerset,	–	July 22,	1/8	169.7	18.2
State of Maine,	June 19,	July 24,	1/8	221.2	24.3
State of Wisconsin,	June 19,	July 22,	1/8	121.2	37.3
Table King,	June 23,	July 22,	3/8	230.3	25.8
Thorburn,	June 19,	July 24,	1/8	218.2	48.5
Tonhocks,	June 23,	July 22,	1/8	248.5	37.9

* Ripening.

Variety Test Potatoes, etc. — Continued.

VARIETY.	First Bloom.	Blight begins.	Amount of Blight August 1.	Yield at Rate per Acre. Large, Two Ounces (Bushels).	Yield at Rate per Acre. Small (Bushels).
Uncle Sam, ...	June 19,	July 22,	¼	293.9	12.1
Vanguard, ...	June 19,	July 22,	⅛	277.6	34.9
Vick's Perfection, . .	June 19,	July 22,	⅛	284.9	39.4
Victory, P. and W., . .	June 19,	July 22,	1/16	278.8	36.4
Vigorosa, ...	June 19,	July 24,	⅛	294.0	40.9
Washington, . . .	June 23,	July 24,	1/16	240.9	28.8
White Elephant, . . .	June 19,	July 29,	1/16	218.2	31.4
White Ohio, ...	June 23,	July 22,	¼	230.3	24.3
White Peachblow, . .	June 23,	July 24,	1/16	125.9	42.4
Wisconsin Beauty, . .	June 19,	July 22,	¼	251.5	25.8
Woodbury's White, . .	June 23,	July 22,	1/16	133.3	31.8
Early Andees, . . .	June 23,	July 22,	¼	-	-
Early Dawn, . . .	June 28,	July 20,	¼	-	-
Salzer's Earliest, . . .	June 28,	July 15,	⅞	-	-
Triumph, ...	June 28,	July 15,	15/16	-	-

Variety Test Potatoes. Final Records.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23. Large, Two Ounces or Above (Bushels).	Yield at Rate per Acre, September 22 and 23. Small (Bushels).
Abundance, ...	-	Sept. 6,	230.3	21.2
Acme, ...	Aug. 12,	Aug. 14,	230.3	18.2
Algoma, ...	Aug. 12,	Aug. 24,	200.0	42.4
American Beauty, ...	Aug. 12,	Aug. 24,	266.7	12.1
Arizona, ...	Aug. 14,	Aug. 24,	236.4	30.3
Bartlett, ...	-	Sept. 5,	330.0	28.8
Beauty of Hebron, ...	Aug. 24,	Sept. 5,	342.5	48.5
Burpee's Superior, ...	-	Sept. 5,	266.7	30.3
Burr's No. 1, ...	Aug. 12,	Aug. 29,	351.5	36.4
Cambridge Russet, ...	Aug. 12,	Aug. 24,	233.4	22.7
Carmen No. 1, ...	Aug. 12,	Aug. 24,	287.9	36.4
Champion of the World, . . .	Aug. 24,	Sept. 5,	269.7	42.4
Clay Rose, ...	Aug. 20,	Aug. 30,	281.8	33.3

Variety Test Potatoes, etc. — Continued.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Commercial,	Aug. 14,	Aug. 30,	197.0	3.0
Country Gentleman,	Aug. 20,	Aug. 30,	315.2	51.5
Dakota Red,	Aug. 19,	Aug. 24,	206.1	18.2
Dreer's Standard,	Aug. 20,	Aug. 30,	312.1	18.2
Dutton's Seedling,	Aug. 20,	Aug. 30,	363.7	60.6
Early Kansas,	Aug. 20,	Aug. 30,	330.3	30.3
Beauty of Hebron,	Aug. 24,	Sept. 5,	393.9	39.4
Early Minnesota,	Aug. 20,	Aug. 30,	278.8	12.1
Early Roberts,	Aug. 12,	Aug. 23,	315.2	54.5
Early Rochester,	Aug. 28,	Aug. 30,	278.8	21.2
Early Rose,	Aug. 20,	Aug. 30,	351.5	66.7
Early Sunrise,	Aug. 20,	Aug. 23,	309.1	75.8
Extra Early Vermont,	Aug. 12,	Aug. 23,	327.3	60.6
Empire State,	Aug. 12,	Aug. 30,	206.1	24.3
Enormous,	Aug. 12,	Aug. 30,	397.0	15.2
Everett,	Aug. 23,	Aug. 30,	215.2	66.7
Fillbasket,	Aug 20,	–	416.2	45.5
Garfield,	Aug. 20,	Aug. 30,	236.4	30.3
German Queen,	–	Aug. 30,	275.8	36.4
Good Times,	–	–	229.1	27.3
Governor Rusk,	Aug. 14,	Aug. 23,	275.8	9.1
Green Mountain,	–	–	242.5	24.3
Howard,	Aug. 12,	Aug. 30,	403.1	51.5
Hurst,*	–	Aug. 8,	193.7	38.2
Mill's Longkeeper,†	–	Sept. 5,	177.6	46.7
Irish Cobbler,	Aug. 12,	–	297.0	45.5
Joseph,	Aug. 12,	Aug. 30,	260.6	30.0
King of the Earliest,	Aug. 12,	Aug. 14,	263.6	51.5
King of the Roses,	–	–	327.3	54.5
Lakeside Champion,	–	Aug. 30,	254.6	45.5
Late Puritan,	Aug. 23,	–	336.4	39.4
Lee's Favorite,	Aug. 14,	Aug. 24,	290.9	66.7
Leonard Rose,	Aug. 22,	Sept. 5,	345.6	57.6
Lincoln,	–	Sept. 5,	357.6	30.3
Maule's Thoroughbred,	Aug. 14,	Sept. 5,	321.2	48.5

* Forty-one hills. † Thirty-nine hills.

Variety Test Potatoes, etc. — Continued.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23.	
			Large, Two Ounces or Above (Bushels).	Small (Bushels).
Mayflower,	–	Sept. 5,	218.2	18.3
Mill's Banner,	–	Sept. 5,	272.8	10.6
Mill's Prize,	–	Sept. 5,	290.9	12.1
Money Maker,	–	Sept. 5,	287.9	21.2
Montana Wonder,	Aug. 12,	Aug. 23,	347.0	66.7
New Satisfaction,	Aug. 22,	Sept. 5,	297.0	30.3
Parker's Market,	Aug. 12,	Aug. 23,	234.9	30.3
Penn Manor,	Aug. 12,	Aug. 23,	339.4	60.6
Pingree,	Aug. 20,	Aug. 30,	303.0	24.3
Prince Bismark,	Aug. 12,	Aug. 23,	275.8	60.6
Prize Taker,	Aug. 14,	Sept. 5,	275.8	13.6
Early Potentate,	–	Aug. 23,	230.3	36.4
Pride of Michigan,	Aug. 12,	Aug. 23,	303.0	60.6
Prolific Rose,	Aug. 14,	Aug. 30,	351.5	97.0
Quick Crop,	Aug. 23,	Aug. 30,	309.1	66.7
Reeve's Rose,	Aug. 23,	Sept. 5,	345.5	54.6
Restaurant,	–	Sept. 5,	339.4	78.8
Rochester Rose,	Aug. 14,	Sept. 5,	303.0	72.7
Rose of Erin,	Aug. 14,	Aug. 20,	254.6	6.1
Rose No. 9,	Aug. 23,	Aug. 30,	236.4	34.9
Secretary Wilson,	Aug. 12,	Aug. 23,	290.9	54.6
Seneca Beauty,	–	Sept. 5,	345.5	60.6
Sir Walter Raleigh,	Aug. 23,	Sept. 5,	260.6	18.2
Sir William,	Aug. 14,	Sept. 5,	309.1	30.3
Signal,	–	Aug. 23,	284.9	54.6
Somerset,	–	Sept. 5,	278.8	18.2
State of Maine,	Aug. 23,	Sept. 5,	333.4	27.3
State of Wisconsin,	–	Sept. 5,	272.8	15.2
Table King,	Aug. 23,	Sept. 5,	300.0	27.3
Thorburn,	Aug. 12,	Aug. 24,	357.6	48.5
Tonhocks,	Aug. 23,	Sept. 5,	327.3	57.6
Uncle Sam,	Aug. 23,	Sept. 5,	330.3	36.4
Vanguard,	–	–	381.8	69.7
Vick's Perfection,	Aug. 12,	Aug. 30,	306.1	63.6
Victory, P. and W.,	Aug. 23,	Aug. 30,	321.2	48.5

Variety Test Potatoes, etc. — Concluded.

VARIETY.	Ripening begins.	Vines Dead.	Yield at Rate per Acre, September 22 and 23. Large, Two Ounces or Above (Bushels).	Small (Bushels).
Vigorosa,	Aug. 23,	Aug. 30,	336.4	48.5
Washington,	Aug. 23,	Sept. 5,	404.6	22.7
White Elephant,	Aug. 23,	Sept. 5,	406.1	63.6
White Ohio,	Aug. 12,	Aug. 14,	272.8	48.5
White Peachblow,	Aug. 14,	Aug. 30,	321.2	60.6
Wisconsin Beauty,	Aug. 12,	Aug. 23,	257.6	48.5
Woodbury's White,	Aug. 23,	Sept. 5,	318.2	33.3
Early Andees,*	Aug. 10,	Aug. 14,	509.1	84.9
Early Dawn,*	Aug. 8,	Aug. 12,	509.1	72.7
Salzers' Earliest,*	–	Aug. 8,	434.4	36.4
Triumph,*	–	Aug. 5,	460.7	72.7

* 20 hills only grown.

Thirty-six varieties produce a yield of 55 pounds or over of large potatoes from forty hills when mature, this yield being at the rate of about 333 bushels per acre. These varieties are the following: Burr's No. 1, 351.5; Dutton's Seedling, 363.7; Beauty of Hebron, 393.9; Early Rose, 351.5; Enormous, 397; Fillbasket, 416.2; Howard, 403.1; Late Puritan, 336.4; Leonard Rose, 345.6; Lincoln, 357.6; Montana Wonder, 347; Penn Manor, 339.4; Prolific Rose, 351.5; Reeve's Rose, 345.5; Restaurant, 339.4; Seneca Beauty, 345.5; State of Maine, 333.4; Thorburn, 357.6; Vanguard, 381.8; Vigorosa, 339.4; Washington, 404.6; White Elephant, 406.1; Early Andees,* 509.1; Early Dawn,* 509.1; Salzer's Earliest,* 434.4; Triumph,* 460.7.

Eleven of these varieties gave at the earlier digging 40 pounds or over of large potatoes, which is at the rate of about 240 bushels per acre. These varieties are: Burr's No. 1, 262.1; Dutton's Seedling, 298.5; Beauty of Hebron, 287.9; Early Rose, 263.6; Enormous, 275.8; Howard, 275.8; Montana Wonder, 260.6; Penn Manor, 284.9; Prolific Rose, 257.6; Vanguard, 277.6; Vigorosa, 294.

* Quantity grown less than 40 sets.

There were besides 19 other varieties giving the same or higher yield at the earlier digging. These varieties are: Carmen No. 1, 295.5; Country Gentleman, 251.5; Dreer's Standard, 272.8; Early Kansas, 298.5; Early Roberts, 300; Early Vermont, 266.7; Irish Cobbler, 260.6; King of the Earliest, 265.2; Lakeside Champion, 245.5; Lee's Favorite, 278.8; Maule's Thoroughbred, 260.6; Prince Bismarck, 269.7; Prize Taker, 244; Secretary Wilson, 266.7; Signal, 251.5; Tonhocks, 248.5; Vick's Perfection, 284.9; Victory, P. and W., 278.8; Wisconsin Beauty, 251.5.

It will be noticed that the old Beauty of Hebron and Early Rose are found in both lists, thus ranking still among the most productive sorts, whether for early or late harvest.

There is surely no lack of good varieties of potatoes to choose from, and between many there can be but little difference in value. A single test does not warrant general conclusions. Good northern-grown seed is in my opinion of more importance than name. It is, however, evident that there are a few varieties on our list which seem unworthy of further trial. Among varieties which have made good yields three or more years may be mentioned: Beauty of Hebron, Dutton's Seedling, Early Rose, Enormous, Fillbasket, Prolific Rose, Restaurant, State of Maine, Thorburn, Vanguard and White Elephant.

Experiments in manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure in rotation upon grass land has been continued. We have three large plots (between two and one-half and four acres each) under this treatment. Under this system each plot receives wood ashes at the rate of 1 ton per acre one year; the next year, ground bone 600 pounds and muriate of potash 200 pounds per acre; and the third year, manure at the rate of 8 tons. The system is so planned that each year we have one plot under each manuring. The manure is always applied in the fall, the other materials early in the spring, — this year April 21 and 22.

Plot 1, which this year received barn-yard manure, applied Nov. 16, 1898, gave a yield at the rate of 2.095 tons of hay and 0.5 ton of rowen per acre; plot 2, which received bone and potash, yielded 2.289 tons of hay and 0.479 ton of rowen; plot 3, which received ashes this year, yielded 1.58 tons of hay and 0.33 ton of rowen per acre. The field has now been eleven years in grass, and during the continuance of the present system of manuring (since 1893) has produced an average product (hay and rowen both included) at the rate of 6,630 pounds per acre. The plots when dressed with manure have averaged 7,027 pounds per acre; when receiving bone and potash, 6,568 pounds per acre; and when receiving wood ashes, 6,294 pounds per acre.

Poultry Experiments.

In experiments completed since our last annual report our attention has been confined exclusively to one point, viz., the comparison of a wide nutritive ration with a narrow ration for egg-production; or, in other words, of a ration in which corn meal and corn were prominent with one in which these feeds were replaced with more nitrogenous foods, such as wheat middlings, wheat and oats. So much greater is the cost of wheat than that of corn, that it seemed desirable to obtain as much evidence bearing upon their relative value for egg-production as possible at an early day. If the latter grain should, on further trial, prove so much superior to wheat as our experiments in 1898 indicated, the knowledge of the fact must prove of enormous value. Accordingly, we reared on the scattered colony plan well-bred pullets of the White Wyandotte, Black Minorca and Barred Plymouth Rock breeds, planning to have two houses (one on each feed) with twenty fowls each of each breed. In introducing purchased cockerels for breeding purposes late in the winter we unfortunately carried contagion, and an obscure form of what is commonly called roup broke out in such aggravated form among the Black Minorcas, that, fearing infection of the fowls in other houses, we killed all the Minorcas. The test with this breed was not, therefore, at all conclusive, and details will not be published. Up to the time the test was closed, however, the corn-fed Minorcas had laid about fifty per cent. more eggs than the others.

General Conditions.

The pullets were first evenly divided into lots of twenty each, being matched in sets of two as closely as possible. Each lot occupied a detached house, including laying and roosting room ten by twelve feet and scratching shed eight by twelve feet, with the run of large yards of equal size whenever weather permitted. The winter tests began October 15 and ended April 22. The hens were all marked with leg bands, as a precautionary measure for the purpose of identification in the case of accidental mixture of fowls.

All the meals and the cut clover were given in the form of a mash, fed early in the morning. At noon a little millet was scattered in the straw with which the scratching sheds were littered. At night the balance of the whole grain was fed (also by scattering in the straw) one hour before dark. The fowls were given what whole grain they would eat up clean. Water, shells and artificial grit were kept before the fowls at all times. About twice a week a small cabbage was given to each lot of fowls, this, like all other food, being weighed. The eggs from each lot were weighed weekly. The fowls were all weighed at intervals of about two months. Sitters were confined in a coop until broken up, being meanwhile fed like their mates.

The prices per hundred weight for foods, upon which financial calculations are based, are shown below: —

Wheat,	$1 60
Oats,	1 00
Millet,	1 00
Wheat bran,	85
Wheat middlings,	85
Gluten feed,	90
Animal meal,	1 75
Cut clover rowen,	1 50
Cabbage,	25
Corn meal,	90
Corn,	90

Narrow v. Wide Ration for Egg-production.

The experiments were in one sense continuous, as the same fowls were used throughout; but it is deemed best to report the results obtained during the cooler months and those of the warmer months separately, one being denominated the *winter experiment*, the other the *summer experiment*. These experiments have for their object testing the correctness of the generally accepted view that the laying fowl should receive feeds very rich in nitrogenous constituents (*i.e.*, should have rations with a narrow nutritive ratio). During the tests of the past year corn has been much more largely used than in 1898. Then it replaced about one-half of the oats and wheat usually fed at night; this year the fowls on the wide ration received at night only corn. The fowls on both rations have received cut clover and animal meal in equal proportions.

The health of the fowls on both rations has been uniformly good through both the winter and summer experiments. As last year, however, it is found to require the exercise of more care to avoid overfeeding and loss of appetite among the corn-fed hens.

Winter Experiment.

This experiment, as has been earlier stated, began October 25. This was much too early to make possible the showing of a good record for total eggs, since the pullets did not begin to lay to any extent until January. The facts that they had been at large until the experiment began, after which they were closely confined, and that, as will be remembered, November and December were very cold and stormy, perhaps in large measure account for this. All details necessary to a full understanding of the experiments and the results, it is believed, will be found in the tables: —

Foods consumed, Narrow v. Wide Ration, October 25 to April 27.

KIND OF FOOD.	WHITE WYANDOTTE.		BARRED PLYMOUTH ROCK.	
	Narrow Ration (Pounds).	Wide Ration (Pounds).	Narrow Ration (Pounds).	Wide Ration (Pounds).
Wheat,	333.00	–	333.00	–
Oats,	55.00	–	60.00	–
Millet,	57.00	56.00	57.50	58.00
Wheat bran,	42.11	42.00	41.30	42.00
Wheat middlings,	42.11	–	41.30	–
Gluten feed,	42.11	–	41.30	–
Animal meal,	42.11	42.00	41.30	42.00
Cut clover rowen,	40.07	40.00	37.80	40.00
Corn meal,	–	111.00	–	111.00
Corn,	–	408.50	–	436.00
Cabbage,	152.38	145.63	152.63	190.75

Average Weights of the Fowls (Pounds).

DATES.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
October 25,	4.3	4.3	4.9+	4.9
January 3,	4.6+	5.0+	5.1	5.6—
March 17,	4.6—	4.7+	5.4—	5.4+
April 27,	4.5—	4.3—	4.9—	4.9+

Number of Eggs per Month, Narrow v. Wide Ration, Winter Test.

MONTHS.	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
October,	-	6	11	7
November,	1	7	18	44
December,	9	33	38	44
January,	50	193	27	83
February,	159	228	57	194
March,	213	177	121	216
April,	179	199	112	168
	611	843	384	755

Narrow v. Wide Ration for Egg-production, Winter Test.

	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
Total dry matter in foods (pounds),	604.47	635.97	603.13	661.52
Number of hen days, not including males,	3,560	3,560	3,424	3,554
Number of hen days, including males,	3,622	3,622	3,548	3,678
Gross cost of food,	$9 26	$7 30	$9 25	$7 68
Gross cost of food per egg (cents),	1.50	.90—	2.41	1.02
Gross cost of food per hen day (cents),	.26—	.20+	.26	.21
Number of eggs per hen day,	.17+	.24—	.11+	.21+
Average weight per egg (ounces),	1.91—	1.82+	1.76	2.09
Total weight of eggs (pounds),	72.90	95.90—	48.24	98.62
Dry matter consumed per egg (pounds),	.99—	.75+	1.57	.88
Nutritive ratio,*	1:4.80—	1:6.30	1:4.80	1:6.30

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

Summer Experiment.

The method of feeding during the summer experiment remained the same as in the winter, save in two particulars: (1) in place of cut clover rowen in the mash every morning, lawn clippings in such quantity as the fowls would eat before wilting were fed three times per week to the hens in all the houses the same, and (2) the feeding of cabbages was discontinued. The yards, twelve hundred square feet in area for each house, were kept fresh by frequent use of the cultivator and spade. The health of all the fowls was good throughout this experiment. The tables give all details: —

Foods consumed, Narrow v. Wide Ration, May 1 to September 27.

KIND OF FOOD.	WHITE WYANDOTTE.		BARRED PLYMOUTH ROCK.	
	Narrow Ration (Pounds).	Wide Ration (Pounds).	Narrow Ration (Pounds).	Wide Ration (Pounds.)
Wheat,	273	–	237	–
Oats,	59	–	52.5	–
Millet,	10	10	8	11
Wheat bran,	56	49	40	42
Wheat middlings,	56	–	40	–
Gluten feed,	56	–	40	–
Meat meal,	56	49	40	42
Corn meal,	–	129.5	–	111
Corn,	–	368	–	300

Average Weights of the Fowls (Pounds).

DATES.	WHITE WYANDOTTE.		BARRED PLYMOUTH ROCK.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
April 27,	4.50	4.30 —	4.90 —	4.90
June 2,	4.14 —	4.41 +	4.86	4.80
August 11,	4.28	4.68 +	4.88	4.88
September 27,	4.53	4.79	4.70	4.91

Number of Eggs per Month, Narrow v. Wide Ration, Summer Test.

MONTHS.	WHITE WYANDOTTE.		BARRED PLYMOUTH ROCK.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
May,	162	181	124	177
June,	140	198	156	217
July,	164	213	140	215
August,	158	213	112	128
September (27 days),	107	110	87	76
	731	915	619	813

Narrow v. Wide Ration for Egg-production, Summer Test.

	White Wyandotte.		Barred Plymouth Rock.	
	Narrow Ration.	Wide Ration.	Narrow Ration.	Wide Ration.
Total dry matter in foods (per cent.),	510.41	534.22	412.44	446.35
Number of hen days, not including males,	2,945	2,913	2,400	2,555
Number of hen days, including males,	3,245	3,213	2,573	2,735
Gross cost of food,	$7 50	$5 86	$6 14	$4 91
Gross cost of food per egg (cents),	1.03	.64	1.00	.60
Gross cost of food per hen day (cents),	.23	.18 +	.24	.18
Number of eggs per hen day,	.25 —	.31 +	.26 —	.32 —
Average weight per egg (ounces),	1.88	1.90	1.82	1.77
Total weight of eggs (pounds),	85.89	108.70	70.40	89.94
Dry matter consumed per egg (pounds),	.70	.58	.67	.55
Nutritive ratio,*	1:4.20	1:6.30	1:4.40	1:6.30

* The term nutritive ratio is used to designate the ratio existing between the total nitrogenous and the total non-nitrogenous constituents of the feeds used, the former being regarded as a unit, and fat multiplied by 2.5.

It will be seen that the results of this year's experiments are in every particular similar to those of the experiments carried out in 1898.

The following are the most essential facts: —

1. The wide (rich in corn) ration appears to be much superior to the narrower ration. In all experiments, both summer and winter, the hens receiving corn have laid many more eggs than those receiving wheat.

2. The differences this year in favor of the wide ration, upon the basis of an equal number of hen days, are as follows: —

White Wyandotte, winter test,	41 per cent.
White Wyandotte, summer test,	24 per cent.
Barred Plymouth Rock, winter test,	91 per cent.
Barred Plymouth Rock, summer test,	23 per cent.
Last year the winter difference was	25 per cent.
Last year the summer difference was	33⅓ per cent.

3. The total cost of feeds was less for the wide ration, and of course the cost per egg was much less. In the production of one dozen eggs the saving amounted to from 4⅔ to 16¾ cents.

4. The fowls on the wide ration gained more in weight than the others. Although laying many more eggs, they averaged at the end of the summer test nearly one-quarter of a pound each more than the others.

At the close of the summer experiment the fowls were most critically examined by a number of different parties, working independently, and all were unanimous in the conclusion that the corn-fed hens were farther advanced in the moult than the others. In my own opinion, the difference amounted to some two or three weeks in time. The corn-fed hens had shed all their old tail feathers, the others but few; the corn-fed hens had a large share of their new body feathers, the others had not shed the old. It was evident that the corn-fed hens were sure to begin laying again before the cold weather, while it seemed that the others were unlikely to do so. This judgment has been verified, for a small number of the corn-fed hens which were purchased by the writer have already laid one litter of eggs since October 1 and are beginning to lay a second, their plumage having been perfect for many weeks (December 20).

The great importance of an early moult in case hens are to be kept over is recognized by all. It makes all the difference between profit and a probable loss.

Our results with both breeds, both summer and winter, are thus greatly in favor of the ration richer in corn meal and corn. On its side we have: (1) lower cost of feed; (2) from 23 to 91 per cent. more eggs; (3) a far lower cost per egg, making possible a saving of from $4\frac{2}{3}$ to $16\frac{3}{4}$ cents per dozen in the food cost of their production; (4) a greater increase in weight; and (5) a much earlier moult.

It may here be remarked, using the words employed by the writer in a recent article, "that nature is generally a safe guide; 'Biddy,' kept healthy and vigorous, will take corn always in preference to wheat. Man conceived the idea that wheat is better for large egg-production. He has been endeavoring to convince the hen that she doesn't know what is good for her; and now it seems that, after all, her instinct and not his supposedly scientific reasoning has been right."

The writer is aware that under different conditions other results might follow. It is here particularly pointed out that our fowls are given plenty of space and fresh air, and that they are made to scratch vigorously for their whole grain.

REPORT OF THE BOTANISTS.

G. E. STONE, R. E. SMITH.

The work of this division has gone on steadily during the past year, having been almost entirely along the line of vegetable physiology and pathology. A large amount of correspondence has been carried on, along with the work of investigation. A considerable part of the work has been in connection with the growing of green-house crops, as in past years, lettuce, cucumbers and tomatoes receiving especial attention. The investigations outlined in our last report have been continued, and results obtained which in several cases are nearly ready for publication. The only entirely new subject of importance which has been taken up is that of aster diseases, which is referred to more fully later in this report. A bulletin on "The asparagus rust in Massachusetts" has been issued, containing the results of the investigation of this subject up to 1899. A further consideration of the same subject will be found in the present report.

Aster Diseases.

General complaint has been made of late years in all parts of the country of the trouble in growing asters, and at present more or less complete failure is almost universal. We have therefore commenced an investigation of this subject, with a view to ascertaining the exact nature of the trouble, and what may be done to prevent it. A large number of asters were grown during the past season, and, with the experience already gained, it is planned to grow many more next year, under various conditions which have suggested themselves as bearing on the trouble. Some valuable information has already been obtained, and it is hoped that another season's experience will afford considerable insight into the difficulties which now bid fair to prevent the raising of this popular and valuable flower.

Some Prevalent Diseases of the Year.

The following are some rather uncommon diseases which have been unusually prevalent during the past season: —

The Bacterial Cucumber Wilt.

In our last report we gave an account of a wilting of cucumber leaves, due to purely physiological causes. A disease of the same plant, and having a very similar effect, but caused by bacteria, is well known, and appeared in this vicinity in out-of-door cucumbers this year. In this case the bacteria which cause the trouble develop mostly in the ducts of the stem and leaf petioles, multiplying rapidly, and causing a stoppage of the flow of sap and hence a wilting of the leaves. The organisms can be readily seen, oozing out in little drops from the cut ends of affected parts. Pure cultures may be easily obtained from these drops.

No remedy can be given as yet for this disease, other than the removal and burning of affected plants.

A Geranium Disease.

In our annual report for 1897 we described a leaf-spot disease of the cultivated geranium (Pelargonium), which was thought to be caused by bacteria. It appeared at that time in a very wet season, and seemed more a result of the abnormal conditions than a true disease. The same trouble has been abundant during the past season, however, and appears to be a dangerous enemy to the growth of this plant. It causes small yellow and dead spots in the leaves, so that they fall off, and the plant becomes nearly denuded in the worst cases. Examination showed, as before, that the dead spots are full of bacteria, and no other organisms could be found, the former appearing to be the cause of the disease. Attempts were made to isolate the organisms, but thus far without success; apparently it does not flourish under ordinary culture methods and conditions. Nevertheless, we have here, to all appearances, a genuine bacterial disease.

No remedy can be given for this trouble, beyond good cultivation and the production of vigorous plants. Cases have been seen where affected plants lost most of their leaves and produced a new crop, the latter more or less diseased, but still sufficient to present a fairly good appearance. The use of fungicides has no apparent value in such a case as this.

Muskmelon Failures.

Much complaint has been heard during the past season in this and other States of trouble with muskmelons. In our last report we described a disease of this plant caused by a fungus (*Alternaria*). The disease appeared again this year in the same and other places, and some weeks earlier than before, so that spraying experiments which we had planned were begun too late to be of value. Besides this disease, the common anthracnose (*Colletotrichum lagenarium* (Pass.) E. & H.) has been abundant, and very destructive both on muskmelons and watermelons. We saw one field of watermelons of unusually fine appearance completely ruined by this disease within a week. The stems and fruit were the parts most affected. There is every reason to believe that the Bordeaux mixture can be used with profit in these cases; but our experience this year has shown that if the treatment is not begun by July 1 or earlier, before any sign of disease has appeared, it will be entirely useless.

The Maple Leaf Blight. (*Phyllosticta acericola C. & E.*)

This disease, which affects several species of maple, has been known for some time, but has been much more abundant than usual during the past season. We have received it on sugar maple from several different parties. Large dead spots are produced in the leaves, which become curled and distorted, losing all beauty. Beyond this the actual injury to the tree is probably in most cases very slight.

The Chrysanthemum Rust.

This disease, which we first reported in 1897, appears to be on the decline in Massachusetts. It has been quite common the past season in various places, but in most cases has caused no apparent damage.

Some Experiments in growing Violets in Sterilized Soil.

Some experiments have been made this last year with violets, for the purpose of determining the relation between the production of flowers and the occurrence of leaf spots in sterilized and unsterilized soil respectively. For this purpose cuttings were made in the spring from mature plants and put into sterilized sand, after which they were transplanted into sterilized soil and removed out of doors, where they remained during the summer. In the fall they were transferred to the house and planted in a bed divided equally into two sections, each of which consisted of garden soil of good quality. One section of the bed was sterilized and the other section was not, and, in addition to this, the latter was inoculated with the parasitic nematode *Heterodera*. It should be stated, however, that the nematodes were not abundant enough in the inoculated soil to do any harm, as the bed was inoculated some time previous to setting out the violet plants, and, as no host plants were present, they died, or at least they did not gain any foothold upon the violets. The experiment is therefore largely one between sterilized and unsterilized soils.

Sterilizing the soil alone gives rise to beneficial results in the growth of a crop, a fact which we have already called attention to in Bulletin 55, issued from this station, and various experiments on different crops since has demonstrated the same thing.

Both of the beds were under tolerably equal conditions, at least so far as light and moisture were concerned; but a ventilator made some difference in the growth of a few plants in each section. The total number of plants employed in this experiment was fifty-four, and were of the variety known as the Schœnbrun, which is not especially noted as a flower producer.

The following table shows the results of the experiment: —

Table showing the Monthly Production of Violets in Sterilized and Unsterilized Soil.

DATE.	Number of Blossoms picked.		Percentage of Gain.
	Unsterilized Soil.	Sterilized Soil.	
November,	19	38	100
December,	62	101	63
January,	55	125	127
February,	39	72	84
March,	144	250	73
April,	482	510	5
Total,	801	1,096	–
Average,	133	182	36

The results in the preceding table show a considerable increase in the production of blossoms as a result of sterilizing the soil. The percentage of gain of the sterilized plat over that in the unsterilized was 36. It will be observed also that the gain in flower production in general was most marked during the first half of the experiment, and the flower production falls off in the sterilized earths in the succeeding months, until in April, when the experiment was discontinued, the gain was only 5 per cent. over that of the unsterilized. The maximum occurred during the third month (January), although this might not occur in every instance, as a large number of experiments would probably modify these results.

Observations were made in regard to the number of leaf spots in the two plats, with the result that the sterilized plats gave the smallest number, hence showing that vigorous plants are less susceptible to fungi.

The methods employed in sterilizing the soil were the same as those described on page 54 in Bulletin 55, from this station.

In regard to the practice of sterilizing soil for the purpose of growing plants, we will state that, while there is no doubt as to the beneficial results obtained by sterilizing the same soil for two or three crops, it does not necessarily follow that soil will repeatedly stand this treatment and give good crops.

Within the last year sterilized soil has been recommended for home culture purposes, and those who use it claim to have obtained superior results.

The Relationship existing between the Asparagus Rust and the Physical Properties of the Soil.

The past season has been most favorable to the outbreak of the asparagus rust, which has manifested itself in a severe manner in the same localities where it has occurred during the last few years. The unusually dry spring enabled us to predict to asparagus growers the probable occurrence of the rust for last summer; and, as the rust has usually shown itself the season following an outbreak, regardless of the weather conditions, we may expect to encounter the same next summer (1900), at least in those beds which were badly affected and weakened from the attacks of 1899. We have endeavored to point out in Bulletin 61, issued from this station, the relationship existing between dry seasons and the occurrence of the summer or injurious stage of the rust, and also the susceptibility of plants growing in localities possessing soil with little water-retaining properties. Our observations and experiments during the past season have not led us to reverse any of the conclusions set forth in this bulletin, but, on the other hand, we are more strongly convinced of their validity. These conclusions are based upon an extensive study of the localities affected, and the object of the present article is to call attention to additional data relating to the distribution of the rust in Massachusetts, and the relationship existing between the outbreak of the rust and the rainfall, together with the physical properties of the soil. For the past three seasons we have paid attention to the distribution of the rust in Massachusetts, although the regions infected during the past summer (1899) scarcely differ from those infected during previous years.

Attention was first called to the asparagus rust in the fall of 1896. During 1897, although an extremely wet season, the damage by the rust was severe. Its occurrence during this season, however, was merely an after-effect, the primary cause being due to the injury caused by the preceding dry seasons. In 1898 the summer stage of the rust was scarcely perceptible; while in 1899 (the past season) the rust was severe, on account of the want of soil moisture.* The fall stage of the rust (black or teleuto spore stage), which is, according to our estimation, a harmless stage, and not worth paying much attention to, has been universally distributed over the State since 1896. There has, however, been some tendency for it to become less common during the last two years. This stage usually occurs during September and October, about the time when the asparagus plants first commence to lose their green color and turn yellow, the appearance of this stage being associated with the disintegration and death of the plant. The summer stage of the rust (red or uredo stage), which is in every instance an injurious stage, occurs during July and August. It occurs about July 11, or later, on beds from which a crop has been marketed, and spreads very rapidly with the wind, as is evident by those sides of the asparagus plant being first infected which correspond with the prevailing direction of the wind. We have no data as to any earlier appearance of the rust on young plants which have not been cut for the market, and it would not be at all improbable that they become infected earlier than July 11. The summer stage of the rust, however, is limited in its distribution in Massachusetts, and is found only on those soils which are sandy, and possess little water-retaining properties. The sand increases as we approach the sea-coast, and the soils which support asparagus plants affected with the red rust are found with some local exceptions in the eastern part of the State.

The summer stage of the rust has never been observed by us, nor has it been reported (with one exception, which we will refer to later, and which is local) any further west than the towns of Berlin and Northborough, which are east of the

* The amount of rainfall from April 1 to September 1 in 1899, at Amherst, was 14.09 inches; that for the same period in 1898 was 23.97 inches.

meridian 71° 40′. (See map.) These towns would appear to be on the border zone of the uredo spore outbreak, and the occurrence of the rust here is by no means so universal as it is in the sandier region of Cape Cod. Some of the growers situated upon the border zones of infection may have the summer stage badly one season and the next season be free from it. The soil of this region offers sufficient differences in texture from the more sandy coast soils, so that sound, vigorous plants might be expected to be proof against the rust in any season, and the outbreak here might be largely prevented by careful cultivation and feeding of the plants.

An examination of the map (fig. 1) will show those portions of Massachusetts in which the summer stage of asparagus rust has appeared up to the present time. The only region infested with this stage of the rust in Massachusetts west of the meridian 71° 40′ is in the Connecticut valley, in the vicinity of Montague, where the soil is remarkably sandy and dry, while other portions of the Connecticut valley which possess more or less heavier soil have been entirely free from this stage. The affected area shown on the map is characterized by a loose sandy soil, which possesses less water-retaining properties in most instances than the soils of their immediate vicinity. In order, however, to show more definitely the differences existing between the texture of the soils of the eastern part of the State and those of the central and western parts, we have made a number of mechanical analyses of the soils of various regions, which include many from the infected asparagus fields. Any one who has paid special attention to our Massachusetts soils and their influence upon the development of plants would not require a mechanical analysis in order to become convinced of the differences existing between them, as a glance at the soils in the field would be sufficient. Nevertheless, a mechanical analysis will show us the exact differences existing between the textures of the soil of the various regions, and we will moreover be able to demonstrate the amount of difference exhibited in their water-retaining capacity. The following table gives the data of the mechanical analysis*

* The methods of analysis employed are those of Prof. Milton Whitney.

of ten typical surface soils from various parts of the State between the Cape and the New York State line : —

TABLE I. — *Showing the Mechanical Analyses* * *of Ten Massachusetts Soils, extending from Cape Cod to Western Massachusetts. — Average Percentage of Organic Matter, Gravel, Sand, Silt and Clay in 20 Grams of Soil.*

[Diameter of the grains in millimetres (1 millimetre equals about 1/25 inch) : gravel, 2-1; coarse sand, 1-.5; medium sand, .5-.25; fine sand, .25-.1; very fine sand, .1-.05; silt, .05-.01; fine silt, .01-.005; clay, .005-.0001.]

SAMPLE.	Water.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
Orleans,	1.82	2.20	20.97	31.03	19.70	12.26	6.26	2.77	1.46	1.37
Bridgewater,	1.86	2.10	17.92	28.80	18.85	5.80	19.15	2.85	1.34	.66
Eastham,	1.66	2.00	9.38	27.91	25.09	21.43	8.70	1.40	.77	1.43
Concord,	1.66	4.19	4.24	10.20	12.81	27.93	34.11	1.84	1.73	1.08
Attleborough,	8.13	7.64	9.26	11.15	7.87	11.53	29.50	10.95	2.51	1.42
Worcester,	3.00	9.40	1.65	2.80	4.25	19.85	42.95	4.50	2.95	2.75
Spencer,	3.40	9.80	2.70	4.55	7.30	22.35	29.60	6.65	2.45	3.25
Montague,	.90	1.86	.27	4.39	19.85	43.88	25.75	2.63	.36	.27
Amherst,	2.98	7.31	.95	1.25	1.72	7.28	66.19	6.96	1.33	4.13
Pittsfield,	9.50	11.25	5.50	5.95	5.02	13.87	36.15	6.45	.87	5.40

* Analyzed by A. A. Harmon and Asa S. Kinney.

The first six soils represent typical samples taken from affected fields in locations where the summer stage of the rust has always been present since its occurrence in Massachusetts, and in most instances where it has been severe. The other samples are from towns which have not shown the summer stage of the rust, but in which the fall stage has occurred. All of the samples are so-called surface soils, and represent single analyses. Except in the Amherst soils they represent an average of four analyses, while in the Pittsfield there is an average of two. A careful examination of the table will show considerable difference in the texture of the soils of the various regions. It will be observed that the coarse elements are much more common in the coast soils than in the inland soils, and conversely that the fine elements are greatly increased in the inland soils.

In order to obtain a better idea of the relative amounts of the various constituents found in the different soils, we can arrange them as in Table II., in which the average constituents contained in the four coast soils are shown alongside of four inland soils which are characteristic of the central and western regions of Massachusetts. The four coast soils represent badly infested regions, while the four inland soils represent those in which only the fall stage has occurred.

TABLE II. — *Average Percentage of Organic Matter, Gravel, Sand, Silt and Clay in Orleans, Eastham, Concord and Bridgewater (Coast Soils), and Worcester, Spencer, Amherst and Pittsfield (Inland Soils).*

SAMPLE	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
Four coast soils, ...	2.62	13.12	24.48	19.11	16.85	16.80	2.21	1.32	1.13
Four inland soils, . . .	9.44	2.70	2.63	4.57	15.83	18.72	6.14	1.90	3.88

The largest amount of gravel as shown by the table is in the Orleans soil from Cape Cod, which is 20.97 per cent.; the average for the whole is 13.12 per cent., against 2.70 per cent. for the inland soils. What holds true in regard to the gravel is also true when we consider the coarse sand, where the proportion is 24.48 per cent. in the coast soil, to 2.63 per cent. in the inland soils; while in the medium sand it is 19.11 per cent. to 4.57 per cent. Only slight differences are shown in the proportion of fine and very fine sand between the two regions, although the coast soils are ahead in the former and the inland in the latter; whereas in both of the silts and clay the largest amounts are found in the inland soils. If we turn to the organic matter, we find that it is also more abundant in the inland soil than it is in the coast soil. This difference is partly accounted for by the fact that some of the samples of inland soil represent highly manured soils, adapted to intensive cultivation. Even making allowances for this fact, the organic matter would seem higher in the inland soils than in the coast soils, inasmuch as various samples of soil taken from inland localities which were not manured gave an average of about 6 per cent., or about three times as much as that shown by the coast soils. This is not true, however, of the coast soils such as are used for general truck farming, — as in the case of Arlington, for example, — in which instance we would find the percentage of organic matter quite large. The amount of water in the soils differs also, which is caused by the analyses of some of the samples being taken at different times, and from not being subject to the same air-drying conditions. It will also be noticed that the Attleborough soil contains an unusually large amount of silt, — a feature which seems to be peculiar to that soil alone. As a rule, the inland soils contain a very large amount of very fine sand, and this appears to be especially characteristic of the Connecticut valley soils. Some analyses which we have made show that this soil sometimes possesses as much as 75 per cent. of this constituent. It is the excessive amounts of this constituent of the soil which renders the Amherst soil compact, and which gives to it an increased water-retaining capacity. The clay, however, shows a gradual increase as we pass inward, and in a less uniform manner is this exhibited by the silt, which can be seen by examining Table III.

TABLE III. — *Showing the Percentage of Gravel-Sand, Silt and Clay in the Soils shown in Table I.*

SAMPLE.	Gravel-Sand.	Silt.	Clay.
Orleans,	90.22	4.23	1.37
Bridgewater,	90.52	4.16	1.13
Eastham,	92.51	2.17	1.43
Concord,	89.35	3.57	1.08
Attleborough,	69.39	13.46	1.42
Worcester,	71.50	7.45	2.75
Spencer,	66.50	9.10	3.25
Montague,	94.15	2.99	.27
Amherst,	77.39	8.29	4.13
Pittsfield,	66.49	7.32	5.40

There are inland soils which contain considerable amounts of sand, such as the Connecticut valley soils, for example, thus offering exception in this respect to the surrounding localities. The Montague soil is one of these, and it will be noticed by examining Table III. that the percentage of sand is very high in this. It is not, however, the coarser varieties but the finer which predominate, thus differing widely from the sandy soil of Cape Cod. Notwithstanding this variation, a large number of analyses show that the clay appears to follow, as a rule, what might be termed a normal amount for each particular region. It is therefore interesting to note in this connection that the increase of clay as we pass inward is fully as characteristic and uniform in the Massachusetts soils as is the decrease of the sand. The differences existing between the texture of the coast and inland soils are sufficient to exert considerable influence upon the growth of plants. This difference is equally perceptible, whether we see the soils in the field or in a table showing their analyses.

Having paid some attention to the physical properties of a few of our State soils, and their effect upon plant development, we are able to ascertain approximately from a mechanical analysis the characteristic properties of the constituents, and what effect they exert upon the development of certain crops. As a rule, we can divide the various constituents directly in the middle; that is, we can consider the four coarser elements and the four finer constituents by themselves. Such an arrangement of the soils is shown in Table IV.

TABLE IV. — *Showing Soils as in Table I., arranged according to the Percentages of Gravel and Coarse, Medium and Fine Sand, the Very Fine Sand, Silt and Clay being omitted.*

Orleans, ...	83.96	Attleborough, . .	39.81
Eastham, . . .	83.81	Spencer, ...	36.90
Bridgewater, . . .	71.37	Pittsfield, . . .	30.34
Montague, . . .	68.39	Worcester, . . .	28.55
Concord, ...	55.18	Amherst, . . .	11.20

If, for example, a soil is rather low in the constituents represented by the gravel and coarse, medium and fine sand,

and correspondingly high in the remaining constituents, then we possess a soil which is characteristic of the inland types, and will pack down very closely when wet. If, however, the reverse of this is true, we find a loose, pliable soil, such as is found on the coast, which is easily worked and especially adapted for truck farming. The latter soil will not retain much water, it quickly dries out; while the former or inland soil will retain considerable water for a long time, inasmuch as the resistance and relative amount of water maintained by different soils depends upon the volume of space in the soil for the water to enter, which in turn depends upon the number of grains of sand, silt and clay. In sandy soils the space is not divided up as much as in a clay soil; the grains of sand being larger, the spaces between the grains are also larger, there is less friction, and the water moves downward more quickly. The order of arrangement of the soils in Table IV. (which is that relative to the coarse material they contain) follows very closely the water-retaining capacity of the soils, as we shall see when we come to Table V.

These are in part the principal differences existing between the coast and inland soil, with now and then an exception; and the outbreak of the summer or injurious stage of the asparagus rust is always characteristic of those soils which are sandy and porous, and consequently possess little water-retaining capacity, whether they are located near the coast or inland. It should, however, be borne in mind that it is not the percentage of coarse and fine material alone which is responsible for the character of a soil, but the shape and arrangement of its particles exert an influence upon it. Then, again, the organic matter, the depth of the soil and the nature of the sub-soil, as is well known, are important when the question of moisture and dryness is concerned. We have already pointed out that the four soils from the coast contain less organic matter than those from inland soils, and this fact holds good for the Montague sample also. If these soils were richer in organic matter, their water-retaining properties would be increased, and they would become less susceptible to the rust.

In order to test the water-retaining properties of some of these samples of soil, we subjected them to the following treatment. Three hundred grams of the air-dried soils were taken and put into a cylinder three inches wide and six inches high, with a perforated bottom, over which there was placed a layer of filter paper. The cans containing the soil were then weighed, after which the samples were liberally treated with water until they contained all that was possible for them to hold. The cylinders were then set aside, and after the water had stopped dripping they were again weighed, and the additional weight which was due to the amount of water applied was noted. This represented the amount of water which the soils could retain. Other air-dried samples of the same soil were heated in an oven to perfect dryness, and by this means the amount of hygroscopic water was obtained for each. This, being added to the amount of water retained, gave the total water capacity of the soil; and, dividing this sum by the weight of water-free soil, which was obtained by subtracting the hygroscopic water from the original three hundred grams, we obtain the percentage of water which each soil is capable of retaining; or, in other words,

$$\frac{\text{Water retained} + \text{Hygroscopic water}}{\text{Water-free soil}} = \% \text{ of water-retain-}$$

ing capacity.

The following table gives the results of these experiments in the order of water-retaining capacity: —

TABLE V. — *Showing the Retentivity of Soil Moistures in Order of Retaining Capacity.*

SAMPLE.	Water retained (Grams).	Hygroscopic Water (Grams).	Weight of Water-free Soil (Grams).	Percentage of Water retained.
Orleans,	103.0	2.10	297.90	35.28
Bridgewater,	99.5	.66	299.34	37.13
Eastham,	115.9	.78	299.22	38.99
Montague,	144.8	.90	299.10	48.71
Concord,	145.3	2.76	297.24	49.81
Attleborough,	168.9	4.20	295.80	58.52
Amherst,	200.6	2.82	297.18	68.45

As might be expected, the coast soils show the smallest percentage of water-retaining capacity, and this percentage increases as we pass inland to the heavier soils, as would naturally follow. The smallest percentage is shown by the soils from Cape Cod, where there is a considerable amount of coarse material and small amounts of fine material; while the largest percentage is given by the Amherst soil, which contains a larger amount of fine material and a less amount of coarse material than the coast soils. The Amherst soils show 68.45 per cent. water-retaining capacity, against 35.28 per cent. for the Orleans; or, in other words, the Amherst soil possesses nearly twice the water-retaining capacity of the Orleans soil. Only two determinations were made of the water-retaining properties of the soil west of Worcester, one being at Montague, where the summer stage of the rust is present, and the other at Amherst, where it has never occurred. These two determinations are, however, sufficient for our purpose; inasmuch as the preceding table shows that the water-retaining properties of the soil decrease in loose, sandy soil, and increase in fine, compact soil; and, as the mechanical constituents of such soils as the Worcester, Spencer and Pittsfield are larger in fine material and more closely resemble the Amherst soil than those of the coast, we would therefore find similar water-retaining properties.

The cans containing the soils were left in a room of even temperature, and after five days had elapsed they were weighed again, with the following result: —

Table VI. — *Percentage of Water lost by the Following Soils after Five Days.*

Bridgewater, ...	75.07	Attleborough, . .	46.95
Orleans, ...	73.78	Montague, . . .	40.33
Eastham, ...	66.17	Amherst, . . .	23.33
Concord, ...	51.75		

These results follow in a general way those shown in Table V. The Bridgewater, however, lost slightly more than the Orleans. As most of these soils were gathered within a few days of each other, it may be of some interest to note the amount of water found in each at the time the samples reached the laboratory. Amherst gave 33.60 per cent. of water; Montague, 11.26 per cent.; Orleans, 12.50 per cent.; Attleborough, 15.40 per cent.; Concord, 8.65 per cent.; Eastham, 5.69 per cent.; Bridgewater, 3.74 per cent. These figures do not possess any great value, but in a general way they correspond with those in the preceding table. The variation in the amount of rainfall in different parts of the State of course comes into account here. We will state, however, that the Amherst soil referred to was taken from an asparagus bed which has never had the rust in any stage, — a fact which is not only due to its characteristic texture and the nature of the subsoil, but to the fact that the plants have been thoroughly cultivated and properly fed, and consequently are in a very vigorous condition. According to Professor Brooks, this bed has at times received a heavy dressing of cow manure in the fall, which has been forked in in the spring, and then fertilizer has been put on at the following rate per acre: muriate of potash, 600 pounds; nitrate of soda, 200 pounds; and acid phosphate, 900 pounds.

Asparagus growers have stated that there is a difference as to infection in different parts of a field. Many have stated that the drier places were the most badly infested, while others could notice no difference, or in some instances those parts which they considered the least dry showed the rust the worst. This latter condition does not in any way affect our conclusions that the rust (summer stage) is peculiar alone to those regions that possess sandy soil which has little water-retaining capacity, inasmuch as our conclusions are general, and refer to the State as a whole. That exceptions do occur even in a single bed is not at all strange, so long as plants are endowed with a tendency to vary. There are other factors which have a bearing on the susceptibility of plants to rust other than those of soil and water conditions, among which is the general health condition or vigor of the plant. We have repeatedly observed in the same bed numerous plants that were badly infected, while directly beside them were some which were perfectly healthy. We do not maintain, however, that, in a bed where the plants possess the same amount of vigor and where they are under exactly similar conditions except in regard to moisture, those in the dry place will succumb to the rust quickest and become more severely affected than those located in dry places. The principal feature which we wish to emphasize in connection with these experiments is that the summer stage of the asparagus rust is due to a weakened condition of those plants growing on dry soil during seasons of extreme drought. In other words, the plants suffer for water; and, since this is the case, the rational method of prevention must take the amount of soil moisture into consideration. It will not be out of place here to reflect upon the present status of the rust problem, and consider the methods which should be employed in our endeavors to control it.

The practice of spraying, it would seem, is not likely to give promise of any remarkable results, because the asparagus plants offer difficulties in this respect, and all of the rusts are hard to control. Stewart found, in his experiments on spraying for the carnation rust, which attacks a host largely confined to greenhouses and therefore much better under control, that the best results obtained by spraying were not very promising. Then, again, it is possible that the asparagus rust mycelium may be confined to the plant throughout the year, in which case the value of spraying would be practically useless. We have observed a fungous mycelium in the roots and stems of the asparagus plants below the ground long before any occurrence of the rust showed upon the aerial stems; but whether the mycelium was identical with that of the rust, or of other parasitic fungi frequently found upon the asparagus, we were not able to ascertain. We must therefore turn our attention to other methods of control, — to methods which will enable us to keep the plants under more normal conditions during seasons of drought. These methods will consist, first, of securing the most vigorous plants, — a feature which is dependent upon cultivation and the proper kinds and amounts of plant food with which the plants are supplied. There is considerable difference in the plants of various growers in this respect; the most vigorous and largest plants which we have observed were situated in a dry region, subject to uredo infection, but they have never suffered from the rust till this season. The amount of rainfall between April 1 and September 1 of this year has been the lowest for many years, and many beds have shown the summer stage for the first time this year. It is interesting to note, however, that cultivation and skilful plant feeding alone have enabled some beds to suppress the outbreak of the summer stage.

Then, again, the question of soil moisture during dry seasons must be considered. There are different ways of securing this, such as by irrigation, by increasing the organic matter in the soil, or by mulching. In selecting a site for new beds, they should be started on soil possessing some degree of water-retaining capacity, even if such soil is not adapted quite so well for asparagus during ordinary seasons. We are convinced, however, that soils such as the Montague and Attleborough, which appear to be good asparagus soils, possess enough fine material and sufficient water-retaining capacity to prevent the summer outbreak, provided robust plants are secured. In fact, we are informed that the summer stage of the rust has not appeared on the beds at Attleborough from which this sample was taken previous to this year. It is these extremely light, sandy soils that have been selected for the largest asparagus beds, because they appear to be best adapted for its growth. Numerous inquiries from towns adjoining many of these badly infected regions have failed to show any evidence of injuries from the rust, as the texture of the soil is slightly different.

If the asparagus rust continues to cause as much injury in the future as it has in the past, it may become necessary to resort to those soils of a finer texture for the cultivation of this crop. The matter of irrigation would be expensive and not readily resorted to on many beds, while others that we know of could be very easily irrigated by damming a small stream and properly diverting the course of the water. Since the asparagus rust is brought about by drought, and is therefore not likely to cause much injury except during such seasons, the occurrence of the disease can be anticipated. In this respect it differs from other common plant diseases, inasmuch as we have to spray for them every season, whether we know they are going to make their appearance or not. An annual treatment would therefore not be required. It is hoped that some preventive measures, based upon the retentivity or the supplying of soil moisture, will be employed by those growers who are favorably situated and who have suffered from the rust.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

The work of this division the past year has been principally devoted to the observation of the various weather phenomena, together with the reduction of the records and their arrangement in form for preservation.

The usual monthly bulletins, giving the more important daily records and a review of the character of the weather, have been issued, and the annual summary will be published as soon as the records for the year are complete.

Throughout the year the New England section of the United States Weather Bureau has furnished us daily, except Sunday, with the local forecasts of the weather, and the signals have been displayed from the top of the tower. Arrangements have been made to furnish them the weekly snow reports, as heretofore.

The observations relating to soil temperature and moisture by the electrical method, begun two years ago, have been continued this year. Owing to the unsatisfactory results of the previous years, the temperature cells and moisture electrodes were tested and standardized before using them in the field. The temperature cells were placed in water and the resistances observed. After the resistances became constant for each cell, the temperature of the water was taken by a standard thermometer. The resistance of each cell was thus determined, for temperatures varying by about 10° F., for a range exceeding that which it would be subjected to in the field. The cells were afterward placed in soil in a box, and the resistances observed and the temperature computed by the tables in Bulletin No. 7 of the United States Department of Agriculture, Division of Soils, and checked by using a standard thermometer. The standardization of the moisture electrodes was effected by placing them in soil in boxes so arranged as to provide for a proper diffusion throughout the soil of water as added, taking the resistances and computing the percentage of moisture from the weight. When afterward used in the field these electrodes gave more satisfactory results than had before been attained. The results for the corn-growing season of the current year have been worked out. The observations will be continued next year, for purposes of comparison.

The means of the various weather elements for each month and year, for the ten years from 1889 to 1898 inclusive, have been tabulated, and normal conditions for the period deduced. These results are of especial interest for the purpose of noting departures from normal conditions. The tabulations, together with other data of interest, will be found on the following pages.

Meteorological Observatory of the Hatch Experiment Station, Massachusetts Agricultural College, Amherst.

General Summary, 1889–98.

Latitude of observatory, 42° 23′ 48.5″ N.; longitude, 72° 31′ 10″ W. Elevation of ground at base of observatory above mean low water, Boston harbor, 223 feet, as determined by levels connecting with those of the Boston & Maine Railroad. The standard barometer is 50.5 feet above the ground and 273.5 feet above sea level. The Draper self-recording barometer is 51.5 feet above ground. The cup anemometer, pressure anemometer, anemoscope and sun thermometer are located on top of the tower, 72 feet above the ground. All temperatures are taken in the thermometer shelter on the campus, about 4 feet above ground and 220 feet above sea level. The standard rain gauge is on the campus, about 2 feet above the ground and 218 feet above sea level.

Mean Barometer.

[Readings are reduced to freezing and sea-level.]

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean Annual.
1889, ...	30.113	30.238	29.843	29.795	29.916	29.960	29.909	30.008	29.999	30.050	30.040	30.139	30.001
1890, ...	30.191	30.097	29.993	30.098	29.959	29.975	30.019	30.001	30.124	29.880	30.007	30.013	30.030
1891, ...	29.958	30.041	30.099	29.923	29.983	29.919	29.986	29.965	30.114	30.028	30.117	30.081	30.018
1892, ...	29.965	30.106	29.895	29.972	29.943	29.923	29.988	30.017	30.103	29.896	29.988	30.010	29.983
1893, ...	29.951	30.111	30.065	30.086	29.895	30.056	29.968	30.001	30.065	30.126	30.124	30.120	30.047
1894, ...	30.175	30.160	30.088	30.054	30.000	29.997	30.012	30.033	30.143	30.016	30.081	30.148	30.085
1895, ...	30.047	29.918	29.998	30.119	30.097	30.172	30.031	30.016	30.097	30.082	30.187	30.151	30.076
1896, ...	30.158	29.860	29.990	30.143	29.984	29.949	29.974	29.989	30.004	30.011	30.145	30.135	30.028
1897, ...	30.041	30.056	30.036	30.042	29.924	29.901	29.943	29.943	30.091	30.122	30.034	30.036	30.014
1898, ...	29.976	30.052	30.203	29.927	29.937	29.947	30.017	29.959	30.012	30.089	30.010	29.963	30.008
Mean, . . .	30.057	30.064	30.021	30.016	29.964	29.980	29.985	29.993	30.075	30.030	30.073	30.080	30.029

Range of Barometer (in Inches).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Range.
1889, ...	1.62	1.51	1.58	1.16	.75	.97	.68	.66	.98	.96	1.31	1.75	1.81
1890, ...	1.50	1.35	1.08	1.08	.81	.58	.63	1.10	.69	1.09	.98	1.20	1.76
1891, ...	1.93	1.36	1.21	1.42	.79	.53	.74	.61	.73	1.11	1.56	1.22	2.05
1892, ...	1.38	1.65	1.16	1.02	.96	.84	.97	.55	.96	.98	1.00	1.01	1.65
1893, ...	1.53	1.83	1.27	1.25	1.16	.67	.68	.93	.81	1.37	1.16	1.53	1.92
1894, ...	1.89	1.65	1.04	.86	.93	.75	.57	.44	1.11	1.19	1.22	1.23	2.01
1895, ...	1.46	1.88	1.24	1.40	.84	.66	.51	.53	.68	1.09	1.47	1.78	2.27
1896, ...	.97	1.77	1.52	.96	.75	.83	.79	.59	.85	1.10	1.23	1.57	2.22
1897, ...	1.57	1.15	1.74	1.10	.76	.55	.72	.61	.73	1.12	1.48	1.42	1.76
1898, ...	1.43	1.63	1.17	.86	.76	.95	.81	.60	.82	1.19	1.25	1.39	1.75
Mean, ...	1.53	1.58	1.30	1.11	.85	.73	.71	.66	.84	1.12	1.27	1.41	1.92

Maximum Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889, ...	30.82	30.97	30.66	30.54	30:40	30.54	30.35	30.45	30.40	30.52	30.67	30.96	30.97
1890, ...	30.94	30.72	30.56	30.57	30.32	30.28	30.27	30.28	30.42	30.41	30.35	30.61	30.94
1891, ...	30.62	30.69	30.57	30.56	30.44	30.22	30.37	30.27	30.45	30.67	30.74	30.55	30.74
1892, ...	30.67	30.72	30.45	30.53	30.43	30.39	30.50	30.24	30.42	30.43	30.44	30.53	30.72
1893, ...	30.61	30.83	30.63	30.65	30.32	30.36	30.25	30.30	30.45	30.65	30.70	30.92	30.92
1894, ...	30.77	30.89	30.57	30.52	30.50	30.33	30.31	30.24	30.63	30.42	30.73	30.53	30.89
1895, ...	30.61	30.44	30.52	30.70	30.55	30.51	30.33	30.29	30.41	30.67	30.73	30.83	30.83
1896, ...	30.56	30.49	30.62	30.60	30.48	30.42	30.49	30.39	30.40	30.62	30.86	30.94	30.94
1897, ...	30.77	30.70	30.88	30.61	30.36	30.28	30.33	30.18	30.40	30.67	30.60	30.60	30.88
1898, ...	30.61	30.64	30.76	30.34	30.33	30.35	30.44	30.26	30.41	30.46	30.53	30.52	30.76
Mean maximum, .	30.70	30.71	30.62	30.56	30.41	30.37	30.36	30.29	30.44	30.55	30.63	30.70	30.86

Minimum Barometer.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Minimum.
1889,	29.20	29.46	29.08	29.38	29.65	29.57	29.67	29.79	29.42	29.56	29.36	29.21	29.20
1890,	29.44	29.37	29.48	29.49	29.51	29.70	29.64	29.18	29.73	29.32	29.37	29.41	29.18
1891,	28.69	29.33	29.36	29.14	29.65	29.69	29.63	29.66	29.72	29.56	29.18	29.33	28.69
1892,	29.29	29.07	29.29	29.51	29.47	29.55	29.53	29.69	29.46	29.45	29.44	29.52	29.07
1893,	29.08	29.00	29.36	29.40	29.16	29.69	29.57	29.37	29.64	29.28	29.54	29.39	29.00
1894,	28.88	29.24	29.53	29.66	29.57	29.58	29.74	29.80	29.52	29.23	29.51	29.30	28.88
1895,	29.17	28.56	29.28	29.30	29.71	29.85	29.82	29.76	29.73	29.58	29.26	29.05	28.56
1896,	29.59	28.72	29.10	29.64	29.73	29.59	29.70	29.80	29.55	29.52	29.63	29.37	28.72
1897,	29.20	29.55	29.14	29.51	29.60	29.63	29.61	29.57	29.67	29.55	29.12	29.18	29.12
1898,	29.18	29.01	29.59	29.48	29.57	29.40	29.63	29.66	29.59	29.27	29.28	29.13	29.01
Mean minimum,	29.17	29.13	29.32	29.45	29.56	29.62	29.65	29.63	29.60	29.43	29.37	29.19	28.94

Mean Temperature (in Degrees F.).

[Completed from daily maximum and minimum readings.]

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Mean.
1889,*	–	–	–	–	–	–	–	–	–	–	–	–	–
1890,	29.2	32.0	31.0	45.8	56.3	65.3	68.4	67.2	60.4	48.2	37.2	21.8	46.9
1891,	26.4	27.6	32.7	47.5	55.6	65.2	66.3	69.0	64.9	48.7	38.1	36.9	48.2
1892,	23.6	26.1	31.4	45.2	56.0	69.3	69.3	68.9	59.3	48.6	37.8	26.3	46.8
1893,	16.1	22.9	30.4	43.0	55.8	66.9	68.1	69.2	55.8	52.6	38.2	25.5	45.4
1894,	26.4	21.6	39.6	46.7	57.3	67.8	72.9	68.0	65.5	51.5	34.8	26.9	47.9
1895,	23.2	19.5	31.2	45.6	59.7	69.1	67.6	69.7	64.1	45.6	40.7	30.5	47.2
1896,	20.7	25.0	29.2	48.3	61.1	65.0	71.3	68.8	59.5	47.0	42.2	25.6	47.0
1897,	24.7	25.4	33.1	47.1	56.8	62.0	71.6	66.8	60.1	49.8	36.2	28.3	46.8
1898,	21.8	26.1	39.7	42.4	55.3	66.1	70.9	70.2	63.6	51.1	37.5	25.9	47.5
Mean,	23.6	25.1	33.1	45.7	57.1	66.3	69.6	68.6	60.9	49.2	38.1	27.5	47.1

* Records incomplete.

Range of Temperature (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Range.
1889,*	–	–	–	–	–	–	–	–	–	–	–	–	–
1890,	57.0	54.5	69.0	57.5	48.5	47.5	54.0	47.0	52.0	52.0	51.0	48.5	100.5
1891,	52.5	60.0	57.5	61.5	62.0	60.0	48.5	47.5	55.5	69.0	60.5	51.5	100.0
1892,	66.5	53.5	54.5	58.5	56.0	54.0	52.0	44.0	49.0	54.5	53.0	47.0	104.5
1893,	63.0	54.5	48.0	48.5	57.0	52.5	49.5	57.0	51.0	57.0	52.0	64.0	109.0
1894,	52.0	66.0	56.0	63.0	56.0	55.5	50.0	54.0	56.0	43.0	55.0	55.0	115.0
1895,	50.0	55.0	44.0	56.0	62.5	51.0	54.0	52.0	64.0	51.0	57.0	68.0	105.0
1896,	53.0	67.0	52.0	67.5	62.5	51.0	41.0	55.0	57.5	49.0	54.0	62.0	111.0
1897,	51.0	59.0	60.5	60.0	48.0	47.5	36.0	43.0	59.5	63.5	58.0	62.5	102.5
1898,	65.5	73.0	45.5	54.0	46.0	50.0*	56.5	46.5	58.5	59.5	56.0	60.0	115.5
Mean,	56.7	60.3	54.1	58.4	55.4	52.2	48.0	49.6	55.9	55.4	55.2	57.7	107.0

* Records incomplete.

Maximum Temperatures (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889,*	–	–	–	–	–	–	–	–	–	–	–	–	–
1890,	61.5	57.5	62.5	79.5	80.0	88.0	94.0	88.5	80.5	78.0	62.5	43.5	94.0
1891,	52.0	54.0	56.5	79.5	87.0	94.0	90.0	92.5	91.5	89.0	64.0	60.5	94.0
1892,	57.0	46.5	60.5	78.5	84.0	95.0	94.0	94.0	80.0	77.5	67.0	46.0	95.0
1893,	50.0	50.0	52.0	67.5	87.0	94.0	90.5	96.0	81.0	80.0	63.0	52.0	96.0
1894,	53.0	49.0	73.0	79.0	85.0	93.0	98.0	91.0	91.0	75.0	65.0	51.0	98.0
1895,	45.5	45.0	49.0	81.0	92.0	95.0	90.0	90.0	97.0	71.0	72.0	65.0	97.0
1896,	41.0	53.0	57.0	88.5	94.5	90.0	91.0	97.0	88.5	72.0	69.0	52.5	97.0
1897,	51.0	48.0	59.0	80.5	79.5	85.5	91.0	85.0	91.5	84.0	63.0	59.0	91.5
1898,	50.0	54.0	60.0	71.0	78.5	89.5	96.5	91.0	93.0	86.5	62.0	48.0	96.5
Mean maximum,	51.2	50.8	58.8	78.3	85.3	91.6	92.8	91.7	88.2	79.2	65.3	53.1	95.4

* Records incomplete.

Minimum Temperatures (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Minimum.
1889,*	-	-	-	-	-	-	-	-	-	-	-	-	-
1890, ...	4.5	3.0	—6.5	22.0	31.5	40.5	40.0	41.5	28.5	26.0	11.5	—5.0	—6.5
1891, ...	—0.5	—6.0	—1.0	18.0	25.0	34.0	41.5	45.0	36.0	20.0	3.5	9.0	—6.0
1892, ...	—9.5	—7.0	6.0	20.5	28.0	41.0	42.0	50.0	31.0	23.0	14.0	—1.0	—9.5
1893, ...	—13.0	—4.5	4.0	19.0	30.0	41.5	41.0	39.0	30.0	23.0	11.0	—12.0	—13.0
1894, ...	1.0	—17.0	17.0	16.0	29.0	37.5	48.0	37.0	35.0	32.0	10.0	—4.0	—17.0
1895, ...	—4.5	—10.0	5.0	25.0	29.5	44.0	46.0	38.0	33.0	20.0	15.0	—3.0	—10.0
1896, ...	—12.0	—14.0	5.0	21.0	32.0	39.0	50.0	42.0	31.0	23.0	15.0	—9.5	—14.0
1897, ...	0.0	—11.0	—1.5	20.5	31.5	38.0	55.0	42.0	32.0	20.5	5.0	—3.5	—11.0
1898, ...	—15.5	—19.0	14.5	17.0	32.5	39.5	40.0	44.5	34.5	27.0	6.0	—12.0	—19.0
Mean minimum, . .	—5.5	—9.5	4.7	19.9	29.9	39.4	44.8	42.1	32.3	23.8	10.1	—4.6	—11.8

* Records incomplete.

Mean Dew Point (in Degrees F.).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	26.3	21.2	30.4	43.8	52.8	61.1	62.7	59.5	56.9	39.4	38.3	30.9	43.6
1890, ...	23.8	25.2	26.5	35.6	58.0	57.9	61.5	57.2	55.8	41.0	29.7	14.7	40.6
1891, ...	20.7	21.7	22.6	36.3	44.6	57.0	58.5	62.4	58.1	40.6	30.4	28.2	40.1
1892, ...	18.8	20.9	21.5	33.0	44.9	62.3	60.9	62.1	51.9	41.0	32.1	20.5	39.2
1893, ...	13.9	17.3	24.0	31.4	45.7	58.3	58.8	59.9	49.1	44.2	29.9	21.9	37.9
1894, ...	21.6	17.9	31.1	34.2	52.6	57.9	62.4	58.6	56.2	44.6	27.3	22.3	40.5
1895, ...	19.2	17.1	26.2	35.8	48.7	59.6	59.3	60.4	54.8	35.4	34.4	23.6	39.5
1896, ...	14.3	22.0	25.6	35.9	48.3	53.9	62.4	61.7	54.5	42.4	37.7	19.6	39.9
1897, ...	18.0	18.1	26.9	35.7	48.0	53.3	64.6	59.7	52.7	39.0	31.8	24.2	39.6
1898, ...	18.4	21.8	30.5	34.2	48.8	59.3	64.6	64.6	56.9	46.6	32.7	20.8	41.6
Mean, ...	19.5	20.3	26.5	35.6	49.2	58.1	61.6	60.6	54.7	41.4	32.4	22.7	40.2

Mean Relative Humidity.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	79.0	90.0	75.0	78.3	73.8	79.1	78.2	80.4	83.3	75.7	75.4	75.2	78.6
1890, ...	68.2	74.8	77.3	64.7	67.1	71.3	70.1	74.9	80.9	68.2	67.8	67.2	71.1
1891, ...	72.2	69.4	63.7	60.1	59.3	65.3	66.1	70.3	72.1	65.5	68.7	68.7	66.8
1892, ...	73.7	72.8	64.1	54.5	60.3	68.9	65.6	74.9	70.7	65.5	71.0	70.3	67.7
1893, ...	80.2	74.7	71.4	64.8	66.0	71.1	64.8	70.7	72.8	67.0	68.8	80.9	71.1
1894, ...	78.8	77.5	67.5	60.5	65.8	68.1	68.2	69.9	74.4	82.7	70.8	79.0	71.9
1895, ...	82.5	83.9	80.6	68.1	65.0	68.5	72.7	72.7	73.7	69.2	80.5	75.4	74.4
1896, ...	73.3	87.5	85.3	62.0	62.5	67.3	73.1	79.9	84.0	85.1	82.3	79.8	76.9
1897, ...	77.1	75.7	78.9	68.2	71.5	73.3	80.1	79.6	76.6	68.7	83.2	83.9	76.4
1898, ...	85.2	83.1	72.6	72.1	78.4	77.1	79.3	82.1	80.0	83.6	83.4	80.2	79.8
Mean, ...	77.0	78.9	73.6	65.3	67.0	71.0	71.8	75.5	76.6	73.2	75.2	76.1	73.5

Mean Per Cent. of Cloudiness, from Tri-daily Observations.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889,	55	40	63	55	42	53	54	43	65	60	68	61	55
1890,	52	66	66	50	59	50	56	57	59	64	47	53	57
1891,	61	59	55	49	54	47	54	58	50	54	50	51	53
1892,	63	55	45	42	66	50	35	53	29	46	58	45	49
1893,	52	57	46	55	55	58	44	45	46	40	49	54	50
1894,	53	53	55	53	52	54	50	44	53	44	50	44	50
1895,	51	39	55	54	46	48	58	44	42	42	61	45	49
1896,	43	63	54	39	40	47	50	40	52	63	59	42	49
1897,	46	51	56	46	47	47	64	42	39	39	71	68	51
1898,	66	64	53	68	65	57	53	60	48	62	60	66	60
Mean,	54.2	54.7	54.8	51.1	52.6	51.1	51.8	48.6	48.3	51.4	57.3	52.9	52.4

Hours of Bright Sunshine by Sun Thermometer.

YEAR.	January	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Possible hours, . . .	294	296	371	402	453	457	462	429	373	341	293	283	4,454
1889, ...	134	183	138	191	270	277	182	194	120	129	84	108	2,010
1890, ...	112	131	160	245	225	264	289	199	166	129	143	131	2,194
1891, ...	126	124	195	240	226	248	222	204	224	150	141	143	2,245
1892, ...	128	138	196	244	183	218	287	201	234	178	101	144	2,261
1893, ...	130	111	172	166	188	209	259	225	185	182	133	112	2,072
1894, ...	120	121	150	174	208	180	237	237	176	160	128	159	2,051
1895, ...	153	187	172	188	243	246	192	251	254	197	111	169	2,363
1896, ...	157	168	210	258	297	263	260	254	189	115	105	172	2,448
1897, ...	144	154	188	239	236	248	214	274	221	209	90	108	2,325
1898, ...	132	138	200	168	200	270	236	201	218	157	105	113	2,159
Mean, ...	134	145	178	211	228	242	238	224	199	161	114	136	2,212
Mean per cent., . .	45.7	49.0	48.0	52.5	50.3	53.0	51.5	52.2	53.4	47.2	39.0	48.1	49.7

Precipitation (in Inches).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	3.50*	1.46*	1.02*	3.22*	4.18*	5.40*	10.52	2.72	3.17	4.58	6.04	3.57	49.38
1890, ...	2.61	4.20	5.37	1.73	5.39	1.53	5.63	4.88	5.85	7.13	1.32	2.86	48.50
1891, ...	6.75	4.23	2.99	2.66	1.97	4.75	5.28	4.18	2.66	2.94	2.99	5.40	46.80
1892, ...	5.85	1.90	2.40	0.76	6.28	3.46	4.41	6.47	2.16	0.66	4.98	1.01	40.34
1893, ...	3.33	5.75	3.66	4.41	5.02	3.32	2.59	3.49	2.82	4.88	2.81	4.86	46.94
1894, ...	2.16	1.74	1.77	1.83	4.00	3.13	1.55	0.31	4.63	4.85	3.14	3.53	32.64
1895, ...	3.87	1.05	2.71	5.56	2.07	2.76	3.87	3.46	5.04	4.77	5.36	3.94	44.46
1896, ...	1.07	4.67	6.11	1.32	2.58	2.57	4.96	3.84	5.41	3.23	3.03	0.87	39.66
1897, ...	3.00	2.52	3.53	2.42	4.38	6.65	14.51	4.29	1.94	0.73	5.85	7.23	57.05
1898, ...	7.15	3.80	1.63	3.73	5.61	3.69	4.09	6.85	3.65	6.27	5.48	2.30	54.25
Mean, . . .	3.93	3.13	3.12	2.76	4.15	3.73	5.74	4.05	3.73	4.00	4.10	3.56	46.00

* Kindly furnished by Miss S. C. Snell.

Departures from Monthly Normals.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, . .	—.43	—1.67	—2.10	.46	.03	1.67	4.78	—1.33	—.56	.58	1.94	.01	3.38
1890, . .	—1.32	1.07	2.25	—1.03	1.24	—2.20	—.11	.83	2.12	3.13	—2.78	—.70	2.50
1891, . .	2.82	1.10	—.13	—.10	—2.18	1.02	—.46	.13	—1.07	—1.06	—1.11	1.84	.80
1892, . .	1.92	—1.23	—.72	—2.00	2.13	—.27	—1.33	2.42	—1.57	—3.34	.88	—2.55	—5.66
1893, . .	—.60	2.62	.54	1.65	.87	—.41	—3.15	—.56	—.91	.88	—1.29	1.30	.94
1894, . .	—1.77	—1.39	—1.35	—.93	—.15	—.60	—4.19	—3.74	.90	.85	—.96	—.03	—13.36
1895, . .	—.06	—2.08	—.41	2.80	—2.08	—.97	—1.87	—.59	1.31	.77	1.26	.38	—1.54
1896, . .	—2.86	1.54	2.99	—1.44	—1.57	—1.16	—.78	—.21	1.68	—.77	—1.07	—2.69	—6.34
1897, . .	—.93	—.61	.41	—.34	.23	2.92	8.77	.24	—1.79	—3.27	1.75	3.67	11.05
1898, . .	3.22	.67	—1.49	.97	1.46	—.04	—1.65	2.05	—.08	2.27	1.38	—1.26	8.25

Wind Movement (in Miles).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
1889, ...	5,101	4,828	7,068	5,648	4,056	4,056	4,032	2,811	4,310	4,762	2,589	4,445	53,706
1890, ...	4,914	4,616	5,395	5,020	5,284	3,776	3,976	4,116	3,507	4,143	4,228	5,673	54,648
1891, ...	4,954	4,759	6,261	5,484	4,610	3,713	3,907	3,324	3,201	4,319	5,215	5,465	55,212
1892, ...	5,059	3,438	7,046	5,370	5,056	4,500	3,365	3,390	3,672	4,071	5,231	4,522	54,720
1893, ...	4,056	5,242	5,757	5,384	4,833	3,572	3,640	4,126	3,508	4,198	4,179	3,916	52,411
1894, ...	4,193	4,865	4,406	4,105	2,180	1,838	1,109	1,920	1,414	2,540	4,179	3,508	36,257
1895, ...	2,896	3,920	4,360	4,098	4,071	3,050	2,934	3,397	3,444	5,029	4,156	5,506	46,861
1896, ...	4,943	6,445	8,182	4,674	4,838	3,926	4,048	2,968	4,686	4,544	4,654	5,290	59,198
1897, ...	5,501	4,493	5,363	5,523	5,603	4,208	4,007	3,452	3,506	3,938	4,558	4,068	54,220
1898, ...	3,494	3,699	3,864	5,477	4,769	4,162	3,377	3,111	2,787	3,999	4,856	4,830	48,425
Mean, ...	4,511	4,630	5,770	5,078	4,530	3,680	3,439	3,262	3,404	4,154	4,385	4,722	51,566

Maximum Wind Pressure (in Pounds per Square Foot).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889, ...	26.00	24.0	16.75	15.50	9.00	11.50	10.00	6.5	9.75	12.25	14.50	29.0	29.00
1890, ...	27.75	17.5	13.50	11.50	16.50	10.00	9.25	13.0	5.00	11.00	9.50	24.5	27.75
1891, ...	16.25	13.5	10.50	14.00	10.75	10.50	4.50	2.5	4.00	9.50	15.75	14.0	16.25
1892, ...	10.50	11.5	20.50	16.75	15.75	20.50	11.50	7.5	15.50	12.50	16.00	13.5	20.50
1893, ...	12.00	20.0	18.50	24.50	24.75	9.00	13.00	37.5	14.50	23.00	14.00	18.5	37.50
1894, ...	20.00	22.5	11.50	15.50	14.50	14.00	9.50	9.5	13.00	10.00	18.00	15.0	22.50
1895, ...	13.00	25.0	20.00	10.00	7.00	8.00	8.00	5.5	43.00	14.00	22.00	24.0	43.00
1896, ...	15.00	24.5	19.00	18.00	25.00	7.75	8.50	12.5	19.00	12.00	15.00	12.0	25.00
1897, ...	18.50	10.0	13.50	14.00	22.00	7.00	12.00	14.0	20.00	11.50	20.00	12.0	22.00
1898, ...	22.50	15.5	15.50	10.00	18.00	8.50	17.50	13.0	30.50	12.00	19.00	28.0	30.50
Maximum, . . .	27.75	25.0	20.50	24.50	25.00	20.50	17.50	37.5	43.00	23.00	22.00	29.0	43.00

Maximum Velocity of Wind (in Miles per Hour).

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual Maximum.
1889, ...	72	69	58	56	42	48	45	36	44	50	54	76	76
1890, ...	74	59	52	48	57	45	43	51	32	47	44	70	74
1891, ...	57	52	46	53	46	46	30	23	28	44	56	53	57
1892, ...	46	48	64	58	56	64	48	39	56	50	57	52	64
1893, ...	49	63	61	70	70	42	51	87	54	68	53	61	87
1894, ...	63	67	48	56	54	53	44	44	51	45	60	55	67
1895, ...	51	71	63	45	37	40	40	33	93	53	66	69	93
1896, ...	55	70	62	60	71	39	41	50	62	49	55	49	71
1897, ...	61	45	52	53	66	37	49	53	63	48	63	49	66
1898, ...	67	56	56	45	60	41	59	51	78	49	62	75	78

Snow, Frost and Weather.

YEAR.	Last Snow.	First Snow.	Total Snowfall (Inches).	Last Frost.	First Frost.	Number of Days .01 Precipitation.	Number of Clear Days.	Number of Fair Days.	Number of Cloudy Days.
1889, ...	April 2,	Oct. 13,	26.0	May 26,	Sept. 21,	119	94	110	161
1890, ...	April 8,	Oct. 19,	43.5	May 12,	Sept. 25,	141	137	105	123
1891, ...	May 5,	Nov. 26,	54.2	May 19,	Oct. 12,	112	145	103	117
1892, ...	April 10,	Nov. 5,	42.5	May 10,	Sept. 30,	108	123	109	134
1893, ...	April 21,	Nov. 4,	74.3	May 8,	Sept. 3,	143	101	96	168
1894, ...	April 12,	Nov. 5,	71.5	May 22,	Aug. 22,	125	107	83	175
1895, ...	April 3,	Oct. 20,	61.0	May 17,	Aug. 22,	119	118	110	137
1896, ...	April 7,	Nov. 14,	44.0	May 1,	Sept. 24,	108	132	102	132
1897, ...	April 27,	Nov. 12,	52.8	May 8,	Sept. 22,	127	108	109	148
1898, ...	April 6,	Nov. 24,	69.5	April 27,	Sept. 21,	135	78	138	149

Summary for the Ten Years 1889–98.

Barometer (Pressure in Inches).

Maximum, reduced to freezing, Feb. 26, 1889, 11 A.M.,	30.650
Minimum, reduced to freezing, Feb. 8, 1895, 7 A.M.,	28.240
Maximum, reduced to freezing and sea level, Feb. 26, 1889, 11 A.M.,	30.970
Minimum, reduced to freezing and sea level, Feb. 8, 1895, 7 A.M.,	28.560
Mean,	30.029
Total range,	2.410
Greatest annual range, 1895,	2.270
Least annual range, 1892,	1.650
Mean annual range,	1.920
Greatest monthly range, January, 1891,	1.930
Least monthly range, July, 1895,	.510
Mean monthly range,	1.090

Air Temperature (in Degrees F.).

Highest, July 20, 1894, 5 P.M.,	98.000
Lowest, Feb. 3, 1898, 6 A.M.,	—19.000
Mean,	47.100
Total range,	117.000
Greatest annual range, 1898,	115.500
Least annual range, 1891,	100.000
Mean annual range,	107.000
Greatest monthly range, February, 1898,	73.000
Least monthly range, July, 1897,	36.000
Mean monthly range,	54.900
Greatest daily range, Feb. 18, 1892,	52.500
Least daily range, April 5, 1898,	2.500
Mean daily range,	22.100

Humidity.

Mean dew point,	40.200
Mean force of vapor,	.430
Mean relative humidity,	73.500

Precipitation (in Inches).

Total rain or melted snow,	460.000
Total snowfall,	539.300
Greatest annual precipitation, 1897,	57.050
Least annual precipitation, 1894,	32.640
Mean annual precipitation,	46.000
Greatest monthly precipitation, July, 1897,	14.510
Least monthly precipitation, October, 1892,	.660
Mean monthly precipitation,	3.830

Greatest in twenty-four hours, July 12-13, 1897,	5.650
Greatest in one hour, July 30, 1898,	1.500
Unusual rains: 1889, June 15, 2.10 inches in four hours; 1896, July 7, 1.10 inches in thirty minutes; 1897, June 9, 4.08 inches in twenty hours; July 13–14, 8 inches in forty-four hours; 1898, July 30, 2.65 inches in two hours; September 10, .95 inch in twenty minutes. Number of days on which .01 inch or more rain or melted snow fell,	1,241.000

Wind (in Miles).

Total movement,	515,638
Greatest annual movement, 1896,	59,198
Least annual movement, 1894,	36,257
Mean annual movement,	51,566
Greatest monthly movement, March, 1896,	8,182
Least monthly movement, July, 1894,	1,109
Mean monthly movement,	4,297
Greatest daily movement, Nov. 27, 1898,	675
Least daily movement, Sept. 29, 1894, and March 7, 1895,	–
Mean daily movement,	141
Maximum pressure per square foot, 43 pounds, = 93 inches per hour, Sept. 11, 1895, 3 P.M.	

Weather.

Mean cloudiness observed,	52.40 per cent.
Total cloudiness by the sun thermometer,	22,400 = 50.30 per cent.
Number hours bright sunshine recorded,	22,120 = 49.70 per cent.
Number of clear days,	1,143
Number of fair days,	1,065
Number of cloudy days,	1,444

Gales of 75 or more miles per hour: 1889, Dec. 26, 76, N.W.; 1893, Aug. 29, 87, S.W.; 1895, Sept. 11, 93, N.E.; 1898, Sept. 7, 78, S.W.; Dec. 4, 75, E.S.E.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The lines of experimentation carried on by this division have been kept strictly within the limits of practical horticulture, devoting especial attention to the growth of common fruit and garden crops, and their protection from insect and fungous pests.

New varieties of fruits, vegetables, ornamental trees, shrubs and plants of promise have been obtained and tested under varying conditions, and many new seedlings produced. For the work of testing varieties a large collection of standard varieties from different sections of the country have been obtained, that, when a new variety is to be tested, careful comparison may be made under conditions where the exact value of standard varieties is known. As far as possible, new varieties are grown under many varying conditions, and very careful inquiry is made of their behavior in many localities.

Previous reports have given the number of varieties of the different kinds of fruits, vegetables, flowers, etc., under experiment, to which have been added the following number of new varieties the past season: apples, four; pears, five; plums (domestic), three; plums (Japanese), seven; plums (American), seven; peaches, five; quinces, two; cherries, four; grapes, four, besides numerous seedlings; blackberries, three; red raspberries, two, and a large collection of seedlings; strawberries, twenty, and many seedlings; chestnuts (Japanese, Spanish and native varieties), eight; walnuts (species and varieties), six; several new hardy ornamental trees, shrubs and plants, and many new varieties of ornamental plants for the greenhouse and summer outdoor decoration.

Immediate results are constantly called for in the case of widely advertised new varieties, but such results can be obtained only under a series of seasons and varying conditions of growth. This work of testing varieties is begun at once upon introduction, and is hastened by all possible means.

The experiments under way, in addition to the testing of varieties, are as follows: —

1. The girdling of the grape vine for profit.
2. Spraying fruit trees when in bloom, to change the bearing year.
3. Spraying peach trees during the winter with lime, to protect the flower buds from winter-killing.
4. The use of dilute copper sulfate in place of the ammoniacal carbonate of copper.
5. The testing of insecticides and fungicides.
6. The testing of spraying apparatus.
7. The use of clear kerosene and kerosene and water for the destruction of scale insects and aphides.
8. The protection of young fruit trees from mice.
9. Various kinds of grafting wax.
10. Various methods of grafting.
11. Whole roots and piece roots in apple root-grafting.
12. Different kinds of stocks for the pear.
13. Growing seedling fruit-tree stocks.
14. The use of hydrocyanic acid gas for the destruction of insects under glass.
15. Turf culture *v.* cultivation in growing apples.
16. Amount and kinds of fertilizers needed for best growth of fruits.
17. Green manuring for orchards.
18. Comparative hardiness of varieties of Japanese plums.
19. Growth of lettuce under glass.
20. Growth of tomatoes under glass.

Assistance has been given many horticulturists by visiting their places or answering inquiries by letter, which takes a large share of the time of the head of the division. Assistance has also been given in many places in planning ornamental planting of home and public grounds.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

Since my last report the entomological work of the station has proceeded along its usual lines. A large amount of correspondence has been carried on, and many letters of inquiry from residents of this State have been answered. Believing, however, that the opportunities afforded by this division of the experiment station were either not known of by many, or that the way in which to make use of them was not understood, the following note on the work was prepared: —

Free Aid for the People.

Prevention of Loss by Injurious Insects.

The attacks of injurious insects probably cause the loss of several millions of dollars in Massachusetts alone each year. This has not always been the case, but insects are becoming more abundant and consequently more destructive. Much of this destruction, however, could be either in part or wholly prevented if the proper methods of treatment were made use of, and that this is not more frequently done is very unfortunate. It is probable that the reason for the apparent negligence in this regard is due to ignorance as to what the insect is in each particular case, and what to do to prevent its ravages. It is this very uncertainty which results in nothing being done in most cases.

In order to provide this information for residents of the State, the entomological division of the Hatch Experiment Station at Amherst offers its services without charge to all who may desire them. To obtain this assistance, write to the entomologist, Hatch Experiment Station at Amherst, Mass., describing the trouble, and also, if possible, send samples of the injury and the insect causing it, and attention will at once be given to the matter.

As the Hatch Experiment Station of Massachusetts is supported in part by State appropriation, such a use of its facilities by the people of the State is not only justifiable but most desirable, for it was established for just that purpose; and no one who incurs loss by insect ravages can excuse himself for that loss except on the ground of ignorance that such assistance can be obtained.

Over eight hundred of these circulars were sent out to the newspapers, granges and other organizations of the State, with the request that the facts contained therein be given the greatest publicity. As these slips were not circulated till December, 1899, it is not possible to ascertain the results, but a considerable increase in the already large correspondence is anticipated during the coming year.

Last June my assistant, Mr. R. A. Cooley, was appointed professor of zoölogy and entomology at the Montana State College. Mr. Cooley is a careful and thorough investigator, and proved himself a very efficient and valuable assistant to me. The loss of his services rendered necessary the appointment of some one to take his place. As it was advisable for many reasons to obtain a man of large experience, Dr. H. T. Fernald of Pennsylvania, for nine years professor of zoölogy and entomology at the Pennsylvania State College, and for the past two years State entomologist of Pennsylvania, was elected associate entomologist, to take the place made vacant by the resignation of Mr. Cooley.

The San José Scale.

The San José scale is now known to occur in injurious abundance at more than thirty different places in Massachusetts, — in fact, it may be said to be generally distributed over the State. It has probably been introduced from several other States, as there is nothing except the objections of purchasers to prevent its being brought in on every plant purchased. Its presence, however, and the serious destruction it causes, have led a number of States to pass laws excluding all stock from outside their borders unless accompanied by an authorized certificate that the stock had been inspected and no scale found. This action was most inconvenient for Massachusetts nurserymen, who were often thus prevented from filling orders to go to States having such laws. To meet this difficulty, the committee of the trustees of the college, in charge of the experiment station, authorized the entomological division of the station to inspect nurseries when requested to do so by their owners, and to give authorized certificates where no scale is found, charging for this work only the actual expenses incurred. This action was not a required one, and was taken solely for the purpose of accommodating nurserymen, many of whom have already shown their appreciation of the arrangement and have availed themselves of the opportunity thus afforded them.

Bulletin on Chionaspis.

On the 10th of August, 1899, the work of Mr. R. A. Cooley on the different species of *Chionaspis* and *Hemichionaspis* was published in a special bulletin of the station. This bulletin, treating of many of the important scale insects which have recently attracted so much attention because of the injury they do to fruit and other trees, was fully illustrated, and has received high commendation not only in this country but also in Europe.

The Grass Thrips.

Studies on the grass thrips have been continued during the year by Mr. W. E. Hinds, one of the senior students, with most satisfactory results, and are published as an appendix to the college catalogue. As these studies are largely technical, such of the facts as have an economic bearing will also be published in a bulletin for the use of the farmers of the State.

The Clover-head Beetle.

Work on the clover-head beetle (*Phytonomus nigrirostris*) has been continued during the year by Mr. C. M. Walker, and the results are nearly ready for publication. Its life history has been nearly completed, and the best methods of treatment are being investigated. This work will be published as soon as completed.

Raupenleim.

This substance, which is of such value for banding trees liable to the attacks of the canker worms, tussock moth, etc., has heretofore been manufactured by a secret process in Germany. During the past year the chemist of the Gypsy Moth Commission, Mr. F. J. Smith, made experiments at the chemical laboratory of the insectary, to determine its composition. These experiments proved very successful, and in consequence raupenleim can now be manufactured in this country at a low cost. This one discovery has been estimated as worth half a million of dollars to the farmers and fruit growers of the United States.

The Gypsy Moth.

The work of exterminating the gypsy moth, with which I have been connected since 1891, has been carried on during the past year with marked success, and the insect has been reduced to such an extent over almost the entire territory that one who has kept in close touch with the field work for several years past cannot fail to be impressed by the great gain that has been made towards the extermination of this pest.

There is no longer any question, in the minds of those who have made a careful personal investigation of the work throughout the infested territory, that the gypsy moth can be exterminated. Nearly all of the prominent economic entomologists of this country have inspected the work with great care, and have become fully convinced that extermination is possible, if the Legislature each year promptly grants the full appropriation asked for this purpose by the gypsy moth committee. The entire responsibility now rests with the Legislature.

The Brown-tail Moth.

This insect has now become widely distributed in the eastern part of this State, and even extends into New Hampshire; it is therefore believed to be impossible to exterminate this pest with any appropriations that the two States in which it now occurs would be likely to make. When attention was first called to this insect, in the spring of 1897, the matter was laid before Governor Wolcott, who sent a message to the Legislature recommending an appropriation of $10,000 for the extermination of the pest, which then occurred only in a very limited area. It was believed that this amount would be sufficient to stamp out the insect. The Legislature, however, refused to make any appropriation for this purpose, and the inevitable results followed.

In consideration of the failure of the Legislature to prevent the spread of the brown-tail moth over the country, the gypsy moth committee have authorized me, with the assistance of those associated with me, to "collect such information, both in this country and Europe, in regard to the brown-tail moth, and make such experiments with the insect as may be useful to the committee in future dealing with the creature and necessary for the proper enlightenment of the public on the subject, with a view to publish the said information, if it may appear desirable."

In accordance with this action of the gypsy moth committee a large amount of time has already been spent on this work, but it is far from being completed, and it is impossible at present to say just when the work will be ready for publication.

Monograph of the Pyralidæ.

I have been engaged for many years in a critical study of the microlepidoptera of North America, and have already published several monographs on certain families of these insects. I am now at work on a monograph of the Pyralidæ, which will probably be ready for publication some time this year.

The Card Catalogue.

The card catalogue of insects now contains over forty thousand cards, and is continually growing in size, as constant additions are made to it from the new journals and other entomological publications as they are received. Only those insects occurring in North America have been catalogued in the past, but the literature of the scale insects (Coccidæ) of all countries is now being added. This is rendered necessary, as these insects are being imported into our country from different parts of the world without restriction in any State except California.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, F. W. MOSSMAN, B. K. JONES, P. H. SMITH, JR.

Part I. — Laboratory Work.

Outline of Year's Work.

Part II. — Feeding Experiments and Dairy Studies.

Part I.

Extent of Chemical Work.

The work of the chemical laboratory connected with this department has materially increased during the past year, notwithstanding the prolonged illness of Dr. Lindsey, which necessitated a temporary rearrangement of the staff, leaving the bulk of the analytical work to be carried on by two assistants.

There have been sent in for examination 167 samples of water, 144 of milk, 193 of cream, 36 of pure and process butter, 25 of oleomargarine, 147 of feed stuffs and 52 of miscellaneous substances.

In connection with experiments by this and other divisions of the station there have been analyzed 62 samples of milk, 54 of butter and 429 of fodders and feed stuffs.

In addition to the above, 748 samples of commercial concentrated feed stuffs have been collected under the provision of the feed law, of which 736 samples have been tested, either individually or in composite. This makes a total of 2,045 substances analyzed during the year, as against 1,875 last year and 1,147 in the year previous. There have also been carried on for the Association of Official Agricultural Chemists investigations relative to the best methods for the determination of starch, pentosans and galactan in agricultural products.

Character of Chemical Work.

Water. — Sanitary examinations of water have been carried out, as in previous years, according to the Wanklyn process, to determine its general fitness for domestic purposes and for the use of live stock.

Persons whose water supply is other than that of a city or town system should use every possible means to guard it against pollution arising from sinks, vaults and stables, or from the entrance of surface water and animal and vegetable matter. The latter, while not in itself highly injurious to health, is objectionable, as it favors the rapid propagation of bacteria and other micro-organisms. The detection of specific disease germs in water is, however, not a function of the chemist, but of the bacteriologist.

Frequent cases of poisoning result from conducting drinking water through lead pipe, and such a practice cannot be too severely condemned, for the poison, once assimilated, is very difficult to remove from the system. At least five samples examined during the past year have shown its presence. Soft waters as a rule have a much greater solvent action upon lead than hard waters. Wells and springs ought to be thoroughly cleaned at regular intervals.

It is of great importance that the utmost care be exercised in taking the sample for analysis, otherwise the chemical examination, conducted under the most careful and exacting conditions, is of little or no value. The quantity necessary is two to three quarts, collected in a thoroughly cleaned and well-rinsed glass bottle, stoppered with a new cork, over which is to be tied a clean piece of cotton cloth. An air space of about one inch should be left between cork and liquid, to allow for expansion. In case of pond water, the sample should be taken from below the surface, being careful to avoid the surface scum and the sediment at the bottom. The chemist's report upon the character of the water must necessarily be a matter of judgment, based on the analysis and the information furnished by the party sending the sample. Accurate replies to the following questions are necessary to a complete understanding of each case, and are for the interest of the person sending the water: —

1. Sources, whether from spring, stream, pond, reservoir or well.
2. Character of soil in which located.
3. Distance from any possible source of pollution, and character of the same.
4. Kind of pipe used for conducting the water.

Ship samples at once by express, charges prepaid. In making the report of an analysis a printed form is used, which explains the results so as to be readily understood by any one.

The examination of mineral or spring waters for which medicinal properties are claimed, or those intended for commercial purposes, does not fall within the scope of our duties.

Milk. — The samples sent in show a wide variation both in solids and fat, a considerable number falling below the Massachusetts legal standard,* indicating a need on the part of certain milkmen and others of introducing better stock and disposing of inferior animals.

In taking a sample for analysis, mix the entire milking by pouring three or four times from one vessel to another, and immediately fill a pint bottle. Mark each sample, stating kind of milk (whole, skim or buttermilk) and the tests desired, together with the name and address of the shipper; the package to be marked "*Immediate Delivery*," and sent by express, prepaid. Samples sent from a considerable distance should be treated with four drops of forty per cent. formaldehyde (obtained at any apothecary's), to insure the preservation of the sample.

Cream. — Everything said in regard to the sampling and shipping of milk applies equally well to cream.

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* In the months of October, November, December, January, February and March, 13 per cent. solids and 3.7 per cent. fat are required, but during the remainder of the year only 12 per cent. solids and 3 per cent. fat.

Butter. — In connection with the feeding experiments conducted at the barn last season many samples of butter were analyzed, and very thorough examinations of the butter fat, both in regard to its chemical composition and physical properties, were made.

"Renovated" or "process" butter having become of considerable prominence in the market, a law was passed by the last Legislature forbidding its sale except when plainly marked, in one-half inch type, "Renovated butter." Several samples have been identified in this laboratory by means of a microscopical examination, general characteristics of the melted fat and curd, together with the Reichert number; and a much larger number of oleomargarines have been identified by the same methods.

Cattle Feeds. — The feed law passed by the State Legislature, which took effect in July, 1897, is apparently meeting with good success. The work is carried out by this department, the assistants making a semi-annual canvass of the State, taking samples of all the prominent concentrated feed stuffs. The samples so collected are carefully analyzed, and the results published in bulletins from time to time. The purpose of this work is to exclude poor and adulterated feeds, and to maintain products of a uniform grade.

The effect of the law on the quality of cotton seed meal has been very marked. In the earlier collections inferior meals were common, but during the present season but few were found, and the average protein content is many per cent. higher. Low-grade wheat feeds and oat feeds of unknown manufacture still remain in the market, and probably will to some extent until a guarantee is required on all feeds and power given to enforce the same.

Part II.

Feeding Experiments and Dairy Studies.

An investigation was instituted last season to ascertain the effect produced on the quantity and quality of butter fat by feeding ground flax-seed meal containing thirty-six per cent. of oil, as compared with a normal linseed ration.

Following this, a long series of feeding experiments was begun, the object being to demonstrate, if possible, the effect of each of the food components, protein, fat and carbohydrates, as found in different feed stuffs, — linseed meal, gluten meal, cotton seed meal, etc., — upon the composition and physical characteristics of the resulting butter fat. In each case the experiment was compared with a standard ration supposed to be without special effect on the butter fat. It is evident that such a task involves a large amount of careful and long-continued work, but as soon as positive results are obtained they will be published.

Digestion Experiments.

Digestion experiments were conducted last winter and spring in the same careful manner as in previous years, using two or three sheep in each trial. The grains fed were oat feed, Parson's $6 feed, four lots of "Bourbon" distillers' grains (brands X., XX., XXX. and XXXX.), rye distillers' grains, Cleveland flax meal and Chicago gluten meal.

The digestion coefficients, together with complete data, will be reported at a later date.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, CHARLES I. GOESSMANN, SAMUEL W. WILEY.

Part I. — Report on Official Inspection of Commercial Fertilizers.

Part II. — Report on General Work in the Chemical Laboratory.

Part I. — Report on Official Inspection of Commercial Fertilizers and Agricultural Chemicals during the Season of 1899.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 67; of these, 38 have offices for the general distribution of their goods in Massachusetts, 10 in New York, 5 in Connecticut, 3 in Vermont, 3 in Rhode Island, 3 in Canada, 2 in Pennsylvania, 1 in Maine, 1 in New Jersey and 1 in Illinois.

Two hundred and ninety-one distinct brands of fertilizer, including chemicals, have been licensed in the State during the year.

Three hundred and eighty-four samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Three hundred and sixty-two samples were analyzed at the close of November, 1899, representing 289 distinct brands of fertilizer. These analyses were published in three bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 59, March; No. 62, July; and No. 63, November, 1899.

The samples not already analyzed, together with others that may be collected before the first of May, 1900, will be examined with a view of being published in our spring bulletin.

During the season the inspector has caused samples to be taken in the towns and villages distributed throughout the State, and representing each county within the Commonwealth. Wherever more than one sample of a given brand has been collected in different parts of the State, a composite sample has been made up of equal weights of the several samples, and an analysis made of the homogeneous mixture. It is believed that an analysis of this nature more fairly represents the composition of the fertilizer than the analysis of any one sample.

It has not always been possible to secure a complete list of the samples licensed in the State; but as thorough a canvass as possible is annually made, varying more or less the towns to be visited from year to year, as seems advisable to the inspector. The methods of sampling are those laid down by our State laws for the regulation of the trade in commercial fertilizers.

For the readers' benefit the following abstract of the results of our analyses are here inserted: —

	1898.	1899.
(*a*) Where three essential elements of plant food were guaranteed:—		
Number with three elements equal to or above the highest guarantee,	5	16
Number with two elements above the highest guarantee,	17	27
Number with one element above the highest guarantee,	77	73
Number with three elements between the lowest and highest guarantee,	85	88
Number with two elements between the lowest and highest guarantee,	93	84
Number with one element between the lowest and highest guarantee,	54	58
Number with two elements below the lowest guarantee,	19	19
Number with one element below the lowest guarantee,	90	68
(*b*) Where two essential elements of plant food were guaranteed:—		
Number with two elements above the highest guarantee,	5	7
Number with one element above the highest guarantee,	24	32
Number with two elements between the lowest and highest guarantee,	25	20
Number with one element between the lowest and highest guarantee,	17	27
Number with two elements below the lowest guarantee,	2	2
Number with one element below the lowest guarantee,	8	18
(*c*) Where one essential element of plant food was guaranteed:—		
Number above the highest guarantee,	18	10
Number between lowest and highest guarantee,	23	16
Number below lowest guarantee,	15	10

A comparison of the above-stated results of our inspection with the results of 1898 shows, on the whole, a marked superiority in favor of the samples analyzed in 1899.

Wherever a discrepancy has arisen between the results of our analyses and the manufacturer's guarantee, it has been evident that imperfect mixing has been the cause, and not a desire of the manufacturer to place inferior goods on the market. It should be remembered, when purchasing fertilizers, that the responsibility of the manufacturer or dealer ends with furnishing an article corresponding in its composition with the lowest stated guarantee of each of the three essential elements of plant food.

From a careful scrutiny of the results of analyses published in the three bulletins during the year it becomes an easy matter for the farmer to intelligently select his fertilizers for the next year's consumption, always bearing in mind that the fertilizer costing the least per ton is not always the most economical fertilizer to buy, but rather the one that will furnish the greatest amount of nitrogen, potassium oxide and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1898 and 1899 (Cents per Pound).

	1898.	1899.
Nitrogen in ammonia salts,	14.00	15.00
Nitrogen in nitrates,	13.00	12.50
Organic nitrogen in dry and fine ground fish, meat, blood and in high-grade fertilizers.	14.00	14.00
Organic nitrogen in fine bone and tankage,	13.50	14.00
Organic nitrogen in medium bone and tankage,	10.00	10.00
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.50	2.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

The cost of some of the leading forms of nitrogen shows an increase, as compared with the preceding year, 1898.

The above trade values are based on the market cost, during the six months preceding March, 1899, of standard raw materials which are largely used in the manufacture of compound fertilizers found in our markets. The following is a list of such materials: —

Sulfate of ammonia.
Azotine.
Cotton-seed meal.
Linseed meal.
Bone and tankage.
Dissolved bones.
Acid phosphate.
High-grade sulfate of potash.
Sulfate of potash and magnesia.
Sylvinite.
Nitrate of soda.
Dried blood.
Castor pomace.
Dry ground fish.
Dry ground meat.
Ground phosphate rock.
Refuse bone-black.
Muriate of potash.
Kainite.
Crude saltpetre.

How to use the table of trade values in calculating the approximate value of a fertilizer: Calculate the value of each of the three essential articles of plant food (nitrogen, phosphoric acid and potassium oxide, including the different forms of each wherever different forms are recognized in the table) in one hundred pounds of the fertilizer, and multiply each product by twenty, to raise it to a ton basis. The sum of these values will give the total value of the fertilizer per ton at the principal places of distribution. An example will suffice to show how this calculation is made: —

Analysis of Fertilizer (Pounds in One Hundred Pounds of Fertilizer).

Nitrogen,	4
Soluble phosphoric acid,	8
Reverted phosphoric acid,	4
Insoluble phosphoric acid,	2
Potassium oxide (as sulfate),	10

	Value per One Hundred Pounds.	Value per Two Thousand Pounds.
Four pounds nitrogen, at 14 cents,	$0.56×20	=$11.20
Eight pounds soluble phosphoric acid, at 4½ cents,	.36×20	= 7.20
Four pounds reverted phosphoric acid, at 4 cents,	.16×20	= 3.20
Two pounds insoluble phosphoric acid, at 2 cents,	.04×20	= .80
Ten pounds potassium oxide, at 5 cents,	.50×20	= 10.00
Value per ton,		$32.40

The following table gives the average analysis of officially collected fertilizers for 1899: —

NATURE OF MATERIAL.	Moisture.	Nitrogen in One Hundred Pounds.		Phosphoric Acid in One Hundred Pounds.							Potassium Oxide in One Hundred Pounds.	
							TOTAL.		AVAILABLE.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	11.86	2.96	2.82	4.65	3.29	3.19	11.13	8.77	7.94	6.67	5.16	4.92
Ground bones,	5.23	2.99	2.63	-	5.58	18.61	24.19	22.53	5.58	6.67	-	-
Tankage,	5.75	4.88	4.41	-	4.99	14.49	18.66	16.33	5.83	-	-	-
Dissolved bone-black,	14.02	-	-	13.62	2.82	-	16.76	16.00	16.44	15.00	-	-
Wood ashes,	9.50	-	-	-	-	-	1.57	1.00	-	-	6.37	4.50
Cotton-hull ashes,	10.44	-	-	-	6.88	1.28	8.16	8.00	6.88	-	27.74	25.00
Cotton-seed meal,	7.79	7.09	6.96	-	-	-	-	-	-	-	-	-
Nitrate of soda,	1.65	15.71	15.36	-	-	-	-	-	-	-	-	-
Sulfate of ammonia,	1.94	21.00	20.60	-	-	-	-	-	-	-	-	-
High-grade sulfate of potash,	1.17	-	-	-	-	-	-	-	-	-	48.42	48.95
Sulfate of potash and magnesia,	3.93	-	-	-	-	-	-	-	-	-	26.70	25.28
Muriate of potash,	1.43	-	-	-	-	-	-	-	-	-	49.68	50.27

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State of Massachusetts during the Past Year (May 1, 1899, to May 1, 1900), and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.
- Fruit and Root Crop Special.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.
- Animal Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-hull Ashes.

The American Jadoo Co., Philadelphia, Pa.: —
- Jadoo Liquid.

Butchers' Rendering Co., Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

The East India Chemical Works (H. J. Baker & Bro., proprietors), New York, N. Y.: —
- Standard Un X Ld Fertilizer.
- Special Complete Strawberry Manure.
- Special Complete Potato Manure.
- Special Complete Cabbage Manure.
- Special Complete Grass and Lawn.
- Complete Manure for General Use.
- Pure Ground Raw Bone.
- Castor Pomace.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.
- Animal Fertilizer.

Berkshire Mills Co., Bridgeport, Conn.:—
- Complete Fertilizer.
- Ammoniated Bone Phosphate

Hiram Blanchard, Eastport, Me.: —
- Fish, Bone and Potash, ⟨H⟩ B.
- Fish Scrap No. 2, ⟨H⟩ B.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Special Fertilizers.
- Bowker's Potatoes and Vegetables.
- Bowker's Fish and Potash, Square Brand.
- Bowker's Potato Phosphate.
- Bowker's Market-garden Manure.
- Bowker's Sure Crop Phosphate.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Essex County Fertilizer.
- Bowker's Ground Bone.
- Gloucester Fish and Potash.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.
- Wood Ashes.

William E. Brightman, Tiverton, R. I.: —
- Brightman's Potato and Root Manure.
- Brightman's Phosphate.
- Brightman's Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
- Bradley's Dry Ground Fish.
- Bradley's Strawberry Manure.
- Bradley's English Lawn Fertilizer.
- Bradley's New Method Fertilizer.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's Columbian Fish and Potash.

Bradley Fertilizer Co. — *Con.*
Bradley's Circle Brand Extra Fine-ground Bone with Potash.
Bradley's X. L. Phosphate.
Bradley's Potato Manure.
Bradley's Potato Fertilizer.
Bradley's Complete Manures.
Bradley's Fish and Potash.
Bradley's Corn Phosphate.
Bradley's Fine-ground Bone.
Ammoniated Bone Phosphate.
Breck's Lawn and Garden Dressing.
Dissolved Bone-black.
Sulfate of Potash.
Muriate of Potash.
Nitrate of Soda.
Kainite.

Joseph Breck & Sons., Boston, Mass.: —
Breck's Market-garden Manure.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
Church's B. Special Fertilizer.
Church's C. Standard Fertilizer.
Church's D. Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass.: —
Clark's Cove Bay State Fertilizer, G. G.
Clark's Cove King Philip Guano.
Clark's Cove White Oak Pure Ground Bone.
Clark's Cove Bay State Potato Manure.
Clark's Cove Great Planet Manure.
Clark's Cove Bay State Fertilizer.
Fish and Potash.
Potato Fertilizer.
High-grade Sulfate of Potash.
Muriate of Potash.
Nitrate of Soda.

Cleveland Dryer Co., Boston, Mass.: —
Cleveland Fertilizer
Cleveland Potato Phosphate.
Cleveland Superphosphate.
Cleveland Grass Fertilizer.
Cleveland Corn and Grain Phosphate.

E. Frank Coe Co., New York, N. Y.: —
E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
E. Frank Coe's High-grade Potato Fertilizer.

E. Frank Coe Co. — *Con.*
E. Frank Coe's Bay State Phosphate.
E. Frank Coe's Fish Guano and Potash.
E. Frank Coe's Gold Brand Excelsior Guano.
E. Frank Coe's Tobacco and Onion Fertilizer.
E. Frank Coe's Vegetable and Vine Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
Crocker's Vegetable Bone Superphosphate.
Crocker's Special Potato Manure.
Crocker's General Crop Phosphate.
Crocker's A. A. Complete Manure.
Crocker's Potato, Hop and Tobacco Phosphate.
Crocker's Ammoniated Wheat and Corn Phosphate.
Crocker's New Rival Ammoniated Superphosphate.
Crocker's New England Tobacco and Potato Grower.

Cumberland Bone Phosphate Co., Boston, Mass.: —
Cumberland Phosphate.
Cumberland Potato Fertilizer.
Cumberland Concentrated Phosphate.
Cumberland Fertilizer.

Chas. M. Cox & Co, Boston, Mass.: —
Cotton-seed Meal.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
Potato and Root Crop.
Animal Fertilizer.
Blood, Bone and Potash.
Fine Bone,
Tobacco Grower.
Special Formula.
Nitrate of Soda.
Muriate of Potash.
Farm Favorite.

John C. Dow & Co., Boston, Mass.: —
Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
Imperial Liquid Plant Food.
Imperial Liquid Grass Fertilizer.

Elbert & Gardner, New York, N. Y.: —
Cotton-seed Meal.

Wm. E. Fyfe & Co., Clinton, Mass.: —
Canada Wood Ashes.

T. H. Frowley, Brookline, Mass.: —
Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
Garden Special.
Vegetable, Vine and Tobacco.
Northern Corn Special.
General Fertilizer.
Grass and Oats.

Thomas Hersom & Co., New Bedford, Mass.: —
Bone Meal.
Meat and Bone.

F. E. Hancock, Walkerton, Ont., Can.: —
Canada Unleached Hardwood Ashes.

Thomas Kirley, South Hadley Falls, Mass.: —
Pride of the Valley.

Lowell Fertilizer Co., Boston, Mass.: —
Swift's Lowell Bone Fertilizer.
Swift's Lowell Animal Brand.
Swift's Lowell Potato Phosphate.
Swift's Lowell Market Garden Manure.
Swift's Lowell Fruit and Vine.
Swift's Lowell Lawn Dressing.
Swift's Lowell Tobacco Manure.
Swift's Lowell Ground Bone.
Swift's Dissolved Bone and Potash.

Lister's Agricultural Chemical Works, Newark, N. J.: —
Lister's Success Fertilizer.
Lister's Special Potato Fertilizer.
Lister's Celebrated Onion Fertilizer.
Lister's Special Tobacco Fertilizer.
Lister's High-grade Special for Spring Crops.

Lowe Bros. & Co., Fitchburg, Mass.: —
Tankage.

F. R. Lalor, Dunnville, Ontario, Can.: —
Canada Hardwood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
Mapes Bone Manures.
Mapes Superphosphates.
Mapes Special Crop Manures.
Economical Potato Manure.
Tobacco Ash Constituents.
Sulfate of Potash.
Sulfate of Ammonia.
Nitrate of Soda.
Double Manure Salt.

Geo. L. Munroe, Oswego, N. Y.: —
Pure Canada Unleached Wood Ashes.

McQuade Bros., West Auburn, Mass.: —
Fine-ground Bone.

E. McGarvey & Co., London, Ontario, Can.: —
Unleached Hardwood Ashes.

Niagara Fertilizer Works, Buffalo, N. Y.: —
Niagara Wheat and Corn Producer.
Niagara Potato, Tobacco and Hop Fertilizer.

Pacific Guano Co., Boston, Mass.: —
High-grade General Fertilizer.
Soluble Pacific Guano.
Potato Special.
Nobsque Guano.
Grass and Grain Fertilizer.
Pacific Guano with ten per cent. Potash.
Fish and Potash.
Special Potato Manure.

Packers Union Fertilizer Co., New York, N. Y.: —
Animal Corn Fertilizer.
Potato Manure.
Universal Fertilizer.
Wheat, Oats and Clover.
Gardeners' Complete Manure.

A. W. Perkins & Co., Rutland, Vt.: —
Plantene.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
Special Strawberry Brand Fertilizer.
Plymouth Rock Brand.
Special Potato Fertilizer.

Parmenter & Polsey Fertilizer Co. — *Con.*
- P. & P. Potato Fertilizer.
- Star Brand Superphosphate.
- A. A. Brand.
- Ground Bone.
- Muriate of Potash.
- Nitrate of Soda.

Prentiss, Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Superphosphate.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash.

Quinnipiac Co., Boston, Mass.: —
- Quinnipiac Onion Manure.
- Quinnipiac Havana Tobacco Fertilizer.
- Quinnipiac Dry Ground Fish.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Market-garden Manure.
- Quinnipiac Fish and Potash.
- Quinnipiac Grass Fertilizer.
- Quinnipiac Corn Manure.
- Quinnipiac Potato Phosphate.
- Quinnipiac Climax Phosphate.
- Quinnipiac Pure Bone Meal.
- Dissolved Bone-black.
- Nitrate of Soda.
- Muriate of Potash.
- Sulfate of Potash.

The Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Pure Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.
- Hubbard's Potato Phosphate.
- Hubbard's Fertilizer for All Soils and All Crops.
- Hubbard's Fertilizer for Oats and Top-dressing.
- Hubbard's Soluble Potato Manure.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Fairchild's Formula for Corn and General Crops.
- Hubbard's Grass and Grain Fertilizer.

N. Roy & Son, South Attleborough, Mass.: —
- Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
- Essex Fish and Potash.
- Essex Potato Fertilizer.
- Essex Corn Fertilizer.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Complete Manure for Potato, Roots and Vegetables.
- Essex Odorless Lawn Dressing.
- Essex Dry Ground Fish.

Read Fertilizer Co., New York, N. Y. (D. H. Foster, general agent): —
- Read's Standard.
- Practical Potato Special.
- Bone, Fish and Potash.
- Vegetable and Vine.

Lucien Sanderson, New Haven, Conn.: —
- Sanderson's Old Reliable.
- Sanderson's Potato Manure.
- Sanderson's Formula A.
- Sanderson's Blood, Bone and Meat.
- Sanderson's Nitrate of Soda.
- Sanderson's Dissolved Bone-black.
- Sanderson's Sulfate of Potash.
- Sanderson's Muriate of Potash.

Standard Fertilizer Co., Boston, Mass.: —
- Standard Fertilizer.
- Standard Special for Potatoes.
- Standard Guano.
- Standard Complete Manure.

M. L. Shoemaker & Co., Limited, Philadelphia, Pa.: —
- Swift Sure Superphosphate for General Use.

F. C. Sturtevant, Hartford, Conn.: —
- Sturtevant's Granulated Tobacco and Sulphur.

Edward H. Smith, Northborough, Mass.: —
- Smith's Ground Bone.

Thomas L. Stetson, Randolph, Mass.: —
- Ground Bone.

The South Sea Guano Co., Boston, Mass.: —
- South Sea Guano.

E. A. Tompkins, Jamaica Plain, Mass.: —
- Ferti Flora.

Henry F. Tucker Co., Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Imperial Bone Superphosphate.
- Tucker's Special Potato Fertilizer.
- Tucker's Bay State Special.

I. S. Whittemore, Wayland, Mass.: —
- Complete Manure.

Darius Whithed, Lowell, Mass.: —
- Champion Animal Fertilizer.
- Flour of Bone.

The Wilcox Fertilizer Works, Mystic, Conn.: —
- Potato, Onion and Tobacco Manure.
- High-grade Fish and Potash.
- Dry Ground Fish Guano.
- Fish and Potash.

Williams & Clark Fertilizer Co., Boston, Mass.: —
- Ammoniated Bone Superphosphate.
- Prolific Crop Producer.
- Potato Phosphate.
- High-grade Special.
- Royal Bone Phosphate.
- Corn Phosphate.

Williams & Clark Fertilizer Co. — *Con.*
- Potato Manure.
- Grass Manure.
- Fish and Potash.
- Onion Manure.
- Bone Meal.
- Dry Ground Fish.
- Muriate of Potash.
- Sulfate of Potash.
- Nitrate of Soda.
- Dissolved Bone-black.

M. E. Wheeler & Co., Rutland, Vt.: —
- Superior Truck Fertilizer.
- Havana Tobacco Fertilizer.
- Potato Manure.
- Corn Fertilizer.
- Fruit Fertilizer.
- Royal Wheat Grower.
- Grass and Oats.

A. L. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Sanford Winter, Brockton, Mass.: —
- Fine-ground Bone.

J. M. Woodard & Brother, Greenfield, Mass.: —
- Tankage.

Part II. — Report on General Work in the Chemical Laboratory.

CHARLES A. GOESSMANN.

1. Analyses of materials sent on for examination.
2. Notes on wood ashes and condition of the trade.

1. Analyses of Materials sent on for Examination.

During the past season 225 materials have been received, and the results of our examination have been published in detail in bulletins 59, 62 and 63 of the Hatch Experiment Station of the Massachusetts Agricultural College, together with the results of the official inspection of commercial fertilizers.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for analyses, and our publication of results merely refers to the locality they come from. It is evident, from the increase each year of the number of materials sent in for analysis, that there is a growing interest taken in this work, and individuals are realizing the value of such chemical investigations.

The waste products of many industries are of such a nature that their value as manurial substances is unlimited and the current modes of manufacture are constantly undergoing changes which affect seriously their commercial manurial value. A frequent investigation of this class of materials cannot help but prove beneficial to the farmer, and hence arrangements will be made, as in previous years, to attend to the examination of these materials to the full extent of our resources. This work is carried on free of charge to the farmers of this State, the results of analysis being returned in the order of the arrival of samples at the office. Below is given a partial list of materials received during the past season, which shows the general nature of the work: —

- Wood ashes.
- Sulfate of potash.
- Muriate of potash.
- Nitrate of soda.
- Sulfate of ammonia.
- Acid phosphates.
- Sulfate of potash and magnesia.
- Ground bone.
- Complete fertilizers.
- Minerals.
- Liquid fertilizers.
- Soils.
- Dried pig's blood.
- Lime-kiln ashes.
- Glucose sugar refuse.
- Damaged grain.
- Insecticides.
- Composts.
- Refuse from glass factory.
- Cotton-seed meal.
- Cotton-hull ashes.
- Tankage.
- Wool shoddy.
- Jadoo fibre.
- Plaster.
- Forage crops.
- Soot.
- Spent bone-black.
- Brick-yard ashes.
- Sludge.

These, together with other manurial products common to commercial and agricultural industries, are carefully investigated, and the results of our examination are free to those who may desire such information.

2. Notes on Wood Ashes.

This subject has engaged our attention for past seasons and has been discussed at length in previous reports.

During the past year (1899) 24.4 per cent. of the materials sent on for analysis consisted of wood ashes, as against 40.1 per cent. the previous year (1898).

The wood ashes sold for manurial purposes in our State are subject to official inspection, and the dealers in this commodity must secure a license to sell before they can legally advertise their article. The goods must be sold on a guaranteed analysis, stating their percentages of potash and of phosphoric acid present, and this analysis must be fastened to each package or car that contains them. As the dealer is obliged only to guarantee the amount of potash and of phosphoric acid present in the ashes, no objection can be raised regarding the amount of moisture, so long as the specified amount of those two elements is present. Wood ashes ought to be bought and sold by weight and *not* by measure, for both moisture and the general character of foreign matters are apt to seriously affect the weight of a given volume.

	No. of Samples.	
	1898.	1899.
Moisture below 1 per cent.,	–	2
Moisture from 1 to 3 per cent.,	9	6
Moisture from 3 to 6 per cent.,	6	4
Moisture from 6 to 10 per cent.,	20	11
Moisture from 10 to 15 per cent.,	22	28
Moisture from 15 to 20 per cent.,	16	7
Moisture from 20 to 30 per cent.,	6	1
Moisture above 30 per cent.,	–	1
Potassium oxide above 8 per cent.,	4	4
Potassium oxide from 7 to 8 per cent.,	6	9
Potassium oxide from 6 to 7 per cent.,	8	13
Potassium oxide from 5 to 6 per cent.,	22	7
Potassium oxide from 4 to 5 per cent.,	25	19
Potassium oxide from 3 to 4 per cent.,	11	2
Potassium oxide below 3 per cent.,	3	2
Phosphoric acid above 2 per cent.,	6	4
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Phosphoric acid below 1 per cent.,	13	10
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Per cent. mineral matter insoluble in diluted hydrochloric acid: —		
Below 5,	1	–
5 to 10,	16	16
10 to 15,	31	26
15 to 20,	15	7
20 to 30,	13	5
Above 30,	–	2

Cotton-hull Ashes. — This waste product is receiving increased attention from the farmers, and is an article of great merit. The samples received this year analyze from 21 to 29 per cent. of potash, and are especially adapted to tobacco growing on account of the large proportion of carbonate of potash present, this form of potash being the most valuable one known for that purpose.

Sludge. — At the present time the larger cities are collecting all waste débris in reservoirs, and subjecting it to chemical treatment for recovery of fertilizing ingredients. This source of plant food is often within easy reach of the farmer, and may be turned to good advantage, as is seen from the average analysis: nitrogen, 1.31 per cent.; potash, .16 per cent.; phosphoric acid, .86 per cent.; lime, 1.13 per cent.

Hen Manure. — In this ingredient we have a very rich fertilizer and a material that is worthy of careful treatment. To save the nitrogen that otherwise might pass into the air a "fixer" is a necessity. Two samples received at the laboratory were analyzed, as follows: —

SAMPLES.	Nitrogen (Per Cent.).	Potash (Per Cent.).	Phosphoric Acid (Per Cent.).
Sample I.,	.46	1.12	.69
Sample II.,	.42	.43	.63

No. I. was treated with kainite, a material analyzing on an average 16 per cent. potash, and a substance capable of fixing the ammonia, thereby saving this element and at the same time supplementing the manure in potash, — the ingredient which it is deficient in. This application of an ammonia fixer may be applied to all animal refuse products, and, as is seen, has a twofold action, — the saving of nitrogen and the supplementing of potash.

Cotton-seed Meal. — This material still holds its own and is a recognized standard article, a source of nitrogen sought by tobacco growers. Its high standard has been maintained as in previous seasons.

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